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HUMAN COMPUTER INTERFACE

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SYLLABI-BOOK MAPPING TABLE

Human Computer Interface

Syllabi	Mapping in Book
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INTRODUCTION

NOTES

Human Computer Interaction (HCI) or Human Computer Interface (HCI) is a field based in the design and the use of computer technology, which focuses on the interfaces between people (users) and computers. HCI researchers observe the ways humans interact with computers, and they design technologies that let humans interact with computers in novel ways.

Humans interact with computers in many ways; the interface between humans and computers is crucial to facilitate this interaction. HCI is also sometimes termed Human Machine Interaction (HMI), Man-Machine Interaction (MMI) or Computer-Human Interaction (CHI). Desktop applications, Internet browsers, handheld computers, Enterprise Resource Planning (ERP), and computer kiosks make use of the prevalent Graphical User Interfaces (GUI) of today. Voice User Interfaces (VUI) are used for speech recognition and synthesizing systems, and the emerging multi-modal and Graphical User Interfaces (GUI) allow humans to engage with embodied character agents in a way that cannot be achieved with other interface paradigms. The growth in human computer interaction field has led to increase in the quality of interaction. Instead of designing regular interfaces, the different research branches have had a different focus on the concepts of multimodality rather than unimodality, intelligent adaptive interfaces rather than command/action based ones, and finally active rather than passive interfaces.

The Human Computer Interface (HCI) can be described as the point of communication between the human user and the computer. The flow of information between the human and computer is defined as the loop of interaction. On the machine side, techniques in computer graphics, operating systems, programming languages, and development environments are relevant. On the human side, communication theory, graphic and industrial design disciplines, linguistics, social sciences, cognitive psychology, social psychology, and human factors, such as computer user satisfaction are relevant. Due to the multidisciplinary nature of HCI, people with different backgrounds contribute to its success. Poorly designed human-machine interfaces can lead to many unexpected problems.

Researchers in HCI are interested in developing design methodologies, experimenting with devices, prototyping software and hardware systems, exploring interaction paradigms, and developing models and theories of interaction.

This book, *Human Computer Interface*, is divided into four blocks, which are further subdivided into fourteen units. This book provides a basic understanding of the subject and helps to grasp its fundamentals. In a nutshell, it explains various aspects, such as human computer interface, importance of user interface, principles of user interface design, interaction devices, keyboard keys, function keys, pointing devices, speech recognition, handwriting recognition, speech generation, image display, video display, device drivers, color and content, user interface design process, user interface models, design methodologies, human interaction with

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computers, human interaction speeds, human consideration in design, graphical user interface, popularity of graphics, web user interface - characteristics and popularity, device and screen-based controls, design goals, screen and web page, organizing screen elements, windows, components of window, window presentation styles, types of windows, window management, understanding business functions, requirement analysis, design standards or style guides, system training and documentation, software tools specification methods, interface building tools, interface mockup tools, software engineering tools, windowing system layer, GUI toolkit layer, information search and visualization, database query, phrase search in documents, multimedia document searches, advanced filtering, hypertext, web technology, static web content and dynamic web content, response time, dealing with time delays, echo delay, file delay, blinking for attention, use of sound, usability and prototypes usability, purpose of usability, usability testing, prototypes, interactive paper prototypes, prototype-oriented languages and comparisons of prototypes.

The book follows the Self-Instructional Mode (SIM) wherein each unit begins with an 'Introduction' to the topic. The 'Objectives' are then outlined before going on to the presentation of the detailed content in a simple and structured format. 'Check Your Progress' questions are provided at regular intervals to test the student's understanding of the subject. 'Answers to Check Your Progress Questions', a 'Summary', a list of 'Key Words', and a set of 'Self-Assessment Questions and Exercises' are provided at the end of each unit for effective recapitulation.

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BLOCK - I
HUMAN COMPUTER INTERFACE AND INTERACTION DEVICES

UNIT 1 HUMAN COMPUTER INTERFACE

Structure

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1.1 Objectives
1.2 Human Computer Interface and Its Importance
  1.2.1 Importance of User Interface
1.3 History of Human Computer Interface
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1.0 INTRODUCTION

The Human Computer Interface (HCI) can be described as the point of communication between the human user and the computer. The flow of information between the human and computer is defined as the loop of interaction. The essence of any human computer interface is to convey information. Visualization has been a good information communication tool for more than two decades. While many visualization systems provide users with a better understanding of their data, they are often difficult to use and are not a reliable, accurate tool for conveying information, which limits their acceptance and use. As scientists, medical researchers, and information analysts face drastic growth in the size of their datasets, the efficient, accurate, and reproducible communication of information becomes essential.

The aim of HCI is to create systems that are both useful and safe, as well as functional. To create usable computer systems, developers must try to understand the elements that influence how people use technology, develop tools and approaches to aid in the development of appropriate systems, and achieve efficient, effective, and safe interaction by putting people first.

The most significant benefit of implementing human computer interaction is the creation of more user-friendly applications. You can make computers and systems more responsive to the user's needs, resulting in a better user experience. This goal-oriented design makes it easier to attain your objectives. That, in turn,

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will lead to higher company success, which is the most important benefit of Human Computer Interface or HCI.

In this unit, you will study about the human computer interface, overview of human computer interface and its history, goals in the field of computers, importance of user interface and its various components.

1.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of human computer interface
- Interpret the components of a human computer interface
- Discuss the various goals of human computer interface
- Understand the importance of user interface
- Explain about the history of user interface

1.2 HUMAN COMPUTER INTERFACE AND ITS IMPORTANCE

The human computer interface can be described as the point of communication between the human user and the computer. The flow of information between the human and computer is defined as the loop of interaction. The loop of interaction has several aspects to it, including:

- Visual Based: The visual-based human computer interaction is probably the most widespread area in Human Computer Interaction (HCI) research.
- Audio Based: The audio-based interaction between a computer and a human is another important area of HCI systems. This area deals with information acquired by different audio signals.
- Task Environment: The conditions and goals set upon the user.
- Machine Environment: The environment that the computer is connected to, e.g., a laptop in a college student's dorm room.
- Areas of the Interface: Non-overlapping areas involve processes of the human and computer not pertaining to their interaction. Meanwhile, the overlapping areas only concern themselves with the processes pertaining to their interaction.
- Input Flow: The flow of information that begins in the task environment, when the user has some tasks that requires using their computer.
- Output: The flow of information that originates in the machine environment.
- Feedback: Loops through the interface that evaluate, moderate, and confirm processes as they pass from the human through the interface to the computer and back.

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- Fit: This is the match between the computer design, the user, and the task to optimize the human resources needed to accomplish the task.

Human Computer Interaction (HCI) is the study of how people communicate with computers and to what extent computers are developed for effective human interaction. Human Computer Interaction (HCI) is a cutting-edge branch of computer science that studies how humans and machines communicate. Card, Moran, and Newell coined the concept in their book 'The Psychology of Human Computer Interaction.' Computer Human Interaction (CHI) is another term for Human Computer Interaction (HCI). Both terms refer to Human Machine Interaction (HMI).

Interface is something that we want it look good and friendly to the end user. The poorly designed interfaces can lead to serious implications and will not be able to engage the end user for the longer period and will reduce the users in future. A poor design may lead to loses money as its workforce is less productive.

Components of HCI

Below are the components of HCI:

- User
- The Machine
- Interaction

Fig. 1.1 *Components of HCI*

User

We may use the word 'User' to refer to an individual user or a community of users working together. It is critical to understand how people's sensory systems (sight, hearing, and touch) transmit information. Furthermore, different users develop different conceptions or mental models about their experiences, and they acquire and retain information in different ways. Cultural and national variations also play a role.

The Machine

When we say 'Computer,' we are talking to a wide range of technology, from desktop computers to large-scale computer systems. If we were talking about the creation of a Website, for example, the Website would be referred to as the machine. Mobile phones and VCRs are examples of devices that can be called computers.

Interaction

Humans and robots have distinct characteristics. Despite this, HCI takes every effort to ensure that they get along and communicate effectively. You must apply

what you know about humans and computers to build a functional framework, and you must communicate with possible users during the design process. The schedule and budget are essential in real-world processes, and they are critical.

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The Goals of Human Computer Interaction

The aim of HCI is to create systems that are both useful and safe, as well as functional. To create usable computer systems, developers must try to understand the elements that influence how people use technology, develop tools and approaches to aid in the development of appropriate systems, and achieve efficient, effective, and safe interaction by putting people first.

Underlying the whole theme of Human computer interaction is the belief that people using a computer system should come first. Their needs, capabilities, and preferences for conducting various tasks should direct developers in the way that they design systems. People should not have to change the way that they use a system to fit in with it. Instead, the system should be designed to match their requirements.

Much of the research in the field of Human Computer Interaction (HCI) takes an interest in:

- Methods for designing new computer interfaces, thereby optimizing a design for a desired property, such as learnability, findability, the efficiency of use.
- Methods for implementing interfaces, e.g., by means of software libraries.
- Methods for evaluating and comparing interfaces with respect to their usability and other desirable properties.
- Methods for studying human computer use and its sociocultural implications more broadly.
- Methods for determining whether the user is human or computer.
- Models and theories of human computer use as well as conceptual frameworks for the design of computer interfaces, such as cognitivist user models, Activity Theory or ethno-methodological accounts of human computer use.
- Perspectives that critically reflect upon the values that underlie computational design, computer use and HCI research practice.

Visions of what researchers in the field seek to achieve might vary. When pursuing a cognitivist perspective, researchers of HCI may seek to align computer interfaces with the mental model that humans have of their activities. When pursuing a post-cognitivist perspective, researchers of HCI may seek to align computer interfaces with existing social practices or existing sociocultural values.

Researchers in HCI are interested in developing design methodologies, experimenting with devices, prototyping software, and hardware systems, exploring interaction paradigms, and developing models and theories of interaction.

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1.2.1 Importance of User Interface

Below are few features of Human Computer Interface (HCI).

- **User-Friendly Applications**

The most significant benefit of implementing human computer interaction is the creation of more user-friendly applications. You can make computers and systems more responsive to the user's needs, resulting in a better user experience. This goal-oriented design makes it easier to attain your objectives. That, in turn, will lead to higher company success, which is the most important benefit of HCI.

- **Increase Customer Acquisition**

A strong user experience will help in attracting and retaining customers. The more customer acquisition will help in building the trust and so will be helpful in retaining for the longer period.

- **Optimize Resources, Development Time and Costs**

A well-designed application or Website work for end users for longer period. It helps in optimizing the resources. The optimizing resource utilization then help in reducing the time and cost of development. On the other hand, poorly, designed application leads to rework of the same application again and again and increase the development cost and time.

- **Increased Productivity**

HCI helps in development of effective, user friendly and easy to use interface. This help in increasing the productivity and so also help in increasing the organization's business. Human computer interaction helps in reducing the errors hence helps in the smoother workflow. A great UI/UX system can also lessen errors and promote a smoother workflow for employees. An effective tip in this regard would be using light colors and highlighting relevant content so that users can see the important information briefly. This will help them focus on the most pertinent information without getting distracted.

- **Software Success**

Human Computer Interaction principles not only important for the end user, but also is an extremely high priority for software development companies. If a software product is unusable and causes frustration, no person will use the program by choice, and as a result sale will be negatively affected.

- **Improved Accessibility**

There are many people with different disabilities. HCI helped in development of such software which can be accessed by not just the normal people but also by the disabled peoples.

1.3 HISTORY OF HUMAN COMPUTER INTERFACE

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Human Computer Interaction (HCI) emerged in the early 1980s, initially as a specialty area in computer science embracing cognitive science and human factors engineering. For three decades, HCI has grown slowly and gradually, attracting people from a wide range of disciplines, and encompassing a wide range of concepts and methodologies. The need for people to communicate with each other has existed since beginning. Movements and gestures are the most basic and widely used means of communication. Language-independent movements and gestures enable people who do not speak the same language to communicate with one another.

Human Computer Interaction (HCI) is a research and practice area that first arose in the late 1970s and early 1980s as a branch of computer science. For three decades, Human Computer Interaction has grown slowly and consistently, attracting people from a wide range of disciplines, and encompassing a wide range of concepts and methodologies.

Wave 1: Desktops & Mental Models

(1980s — 1990s)

During this time, HCI was mainly focused on creating systems that were easy-to-learn and easy-to-use. There were endless possibilities for personal computing, but desktop computers were not very usable tools at first.

Enter the desktop metaphor.

The desktop-folder metaphor was part of a larger effort to apply **mental models** to the way we use computers. By mapping our physical office environment onto computer interfaces, we can more easily grasp how information is store on desktops.

Mental modelling and human factors engineering were the driving factors in software development. This era was all about usability, and we learned a great deal about what people could and could not do while completing tasks on a computer. As designers, we continue to use techniques from this era, such as cognitive walkthroughs, heuristic evaluations, and usability testing. From this point on, it was clear that personal computing was the future. HCI would serve the role of empowering users through the design of intuitive systems.

Wave 2: Collaboration and Communication

(1990s — Early 2000s)

During this era, we shifted our focus from cognitive modelling to interaction design. As computers became communication tools, mental models could no longer explain the broader context of computer use. It became necessary to explore external influences, and to look at how interactions varied across tools and organizations.

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Email gained popularity during this time, which meant that people were not just interacting with computers — they were interacting with *each other* through computers. There was growing interest in how computers were used to support communication and collaboration, signalling the rise of social and organizational computing.

There was a crucial need to understand how interfaces influenced behaviour. As a result, HCI expanded to adopt the expertise of sociologists, anthropologists, and psychologists so they could study the social components of human computer interaction.

As designers, we continue this tradition of using social science methodologies — like ethnography—to inform our work. We help create technologies that facilitate social activity and that enrich the human experience through communication and knowledge sharing.

Wave 3: Self-Expression, Social Change

(Mid 2000s — 2010s)

This is a time of self-expression, self-reflection, and social consciousness. During this era, value-driven design takes the lead in engaging communities and designing for sustainable change. We are encouraged to think about the role of technology in our lives, and the paradox of being "Alone Together" when we shift our attention to personal devices in social settings.

A holistic approach to design emerges as well, emphasizing complex interactions across people, spaces, and technologies. Qualities of pleasure, enjoyment, play, and exploration become central to design.

During this era, HCI draws increasingly from philosophy and ethics to provide rhetoric on the consequences of habit-forming technology, and the responsibility of their creators.

As designers, we become weary of dark patterns. Rather, we craft technologies to enhance the human experience — to encourage people to interact with technology on their own terms, and to support their individual development and aspirations. We strive to address complex and systematic problems through technology and design.

Table 1.1 *History of Computer Interface*

The Rise of the Personal Computer (1970s)
The broad project of cognitive science, which incorporated cognitive psychology, Artificial Intelligence (AI), linguistics, cognitive anthropology, and the philosophy of mind, had formed at the end of the 1970s.
Graphical User Interface (1980s)
The Graphical User Interface (GUI) is a user interface that is designed to make it easier for computer users to understand. There existed a command prompt before GUI, which was used to issue commands to the computers. GUI introduced a graphical user interface that is simple to use, understand, and visualize, thereby improving the working environment.

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The Internet and Collaborative Works (1990s)

In the 1990s, the Internet began its journey. As a result, people were able to communicate more easily. As a result, several new technologies for better communication have emerged.

Mobile Computing and Beyond (2000s)

Mobile phones, PDA (Personal Development Assistance), and Smart Phones are ruling the present world. They offer a wide range of services to the people, such as sms, mms, multimedia, games, email, Internet, chatting, video conference, GPS, etc.

Check Your Progress

1. Define the term Human Computer Interface (HCI).
2. What is loop of interaction?
3. Name another term used for human computer interaction.
4. List the components of human computer interface.

1.4 IMPORTANCE AND BENEFITS OF GOOD DESIGN

The following experimental design principles are considered, when evaluating a current user interface, or designing a new user interface:

- **Early Focus is Placed on the User and Task:** How many users are needed to perform the task is established and who the appropriate users should be is determined (someone who has never used the interface, and will not use the interface in the future, is most likely not a valid user). In addition, the task the users will be performing and how often the task needs to be performed is defined.
- **Empirical Measurement:** The interface is tested with real users who meet the interface daily. The results can vary with the performance level of the user and the typical human computer interaction may not always be represented. Quantitative usability specifics, such as the number of users performing the task, the time to complete the task, and the number of errors made during the task are determined.
- **Iterative Design:** After determining what users, tasks, and empirical measurements to include, the following iterative design steps are performed:
    1. Design the User Interface
    2. Test
    3. Analyze Results
    4. Repeat

The iterative design process is repeated until a sensible, user-friendly interface is created.

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Methodologies

Various strategies delineating methods for human–PC interaction design have developed since the ascent of the field during the 1980s. Most plan philosophies come from a model for how clients, originators, and specialized frameworks interface. Early techniques treated clients' psychological procedures as unsurprising and quantifiable and urged plan specialists to look at subjective science to establish zones, (for example, memory and consideration) when structuring UIs. Present-day models, in general, centre around a steady input and discussion between clients, creators, and specialists and push for specialized frameworks to be folded with the sorts of encounters clients need to have, as opposed to wrapping user experience around a finished framework.

- **Activity Theory:** Utilized in HCI to characterize and consider the setting where human cooperation with PCs occurs. Action hypothesis gives a structure for reasoning about activities in these specific circumstances and illuminates design of interactions from an action-driven perspective.
- **User-Focused Design (UFD):** Client Focused Structure (CFS) is a cutting edge, broadly rehearsed plan theory established on the possibility that clients must become the overwhelming focus in the plan of any PC framework. Clients, architects, and specialized experts cooperate to determine the requirements and restrictions of the client and make a framework to support these components. Frequently, client-focused plans are informed by ethnographic investigations of situations in which clients will associate with the framework. This training is like participatory design, which underscores the likelihood for end-clients to contribute effectively through shared plan sessions and workshops.
- **Principles of UI Design:** These standards may be considered during the design of a client interface: resistance, effortlessness, permeability, affordance, consistency, structure, and feedback.
- **Value Delicate Design:** A technique for building innovation that accounts for the individuals who utilize the design straightforwardly, and just as well for those who the design influences, either directly or indirectly. VSD utilizes an iterative plan process that includes three kinds of examinations: theoretical, exact, and specialized.

Importance of Good Design

A screen's layout and appearance affect a person in a different of ways, so it is important to give importance to the good design. Good design helps the user in communication with the system affectively. So now a day's most of the companies have understood and focusing on the design.

A well-designed interface and screen are especially important for the users. It is their space to work with simple and complex tasks. The structure and appearance of a screen have several effects on an individual user.

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Benefits of Good Design

- Screens looks very friendly and less messy.
- Help in understanding the overall design and so easy to start communication without wasting much time.
- Help in reducing the training time so the cost as well.
- The organization customers benefit because of improved services.
- Less user support costs.
- Increases employee satisfaction is increased because aggravation and frustration are reduced.
- Increased productivity

1.5 PRINCIPLES OF USER INTERFACE DESIGN

An interface can be nothing more than a person's extension. This means that the system and its software must consider a person's abilities and adapt to his or her unique specifications. A good user interface is critical to good user experience. If the interface does not allow people to easily use the Website or app, they will not use the product or they will overwhelm technical support with costs, ballooning costs.

- **Connector and a Separator**

The interface should act as both a connector and a separator: a connector in that it links the user to the computer's control, and a separator in that it reduces the risk of the participants hurting one another.

- **Clarity in Design**

Any interface's first and most critical task is to provide clarity. People must be able to understand an interface you have built to use it effectively. Clarity inspires confidence and encourages continued use. One hundred uncluttered screens are superior to one cluttered screen.

- **Interfaces Exist to Enable Interaction**

Interaction between humans and our world is facilitated by interfaces. They can help us explain, illuminate, allow, display relationships, bring us together, separate us, manage expectations, and provide access to services. The best user interfaces can encourage the good connection to the world.

- **Consistency**

Screen elements do not appear to be consistent with one another unless they behave in the same way. Elements that behave in the same way should have the same appearance. However, unlike elements must appear unlike (inconsistent)

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just as much as like elements must appear consistent. Re-use code helps in maintaining the consistency.

- **Visual Order and Viewer Focus**

The essential and significant elements of the show must be drawn attention to at the appropriate time. It must be obvious that these items can be picked, as well as how to pick them.

- **Effective Visual Contrast**

To achieve this goal, effective visual contrast between different components of the screen is used. Sound and animation are also used to attract focus. The user must also be given feedback.

Importance of User Interface (UI)

User Interface (UI) design is the link between users and application which includes the basic design elements. These design elements need to be present to help the end user to navigate through the application. It makes the relationship of the end user with the application strong and friendly. A good UI then enhance the communication, visibility, and productivity.

A user interface is that portion of an interactive computer system that communicates with the user. Design of the user interface includes any aspect of the system that is visible to the user. Because the user interface design includes everything that is visible to the user, it is deeply ingrained in the overall design of the interactive system. A good user interface cannot be added to a system after it has been developed; it must be designed from the start. A well-designed user interface can significantly reduce training time and improve performance.

The design of a user interface can have a significant impact on training time, performance speed, mistake rates, user happiness, and the user's long-term retention of operations knowledge. In the past, shoddy designs gave way to sophisticated systems.

Design of a User Interface (UI)

Design of a User Interface or UI begins with task analysis—an understanding of the user's underlying tasks and the problem domain. The user interface should be designed in terms of the user's terminology and conception of his or her job, rather than the programmer's. There are several levels of design which are explained below.

Design Levels of a User Interface (UI)

It is helpful to think about the user interface at many levels of abstraction and come up with a design and implementation for each one. This breaks down the developer's workload into smaller chunks, making it easier to manage. The User Interface (UI) is basically into the following:

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Fig 1.2 *Design Levels*

- **Conceptual Level:** The conceptual level describes the basic entities underlying the user's view of the system and the actions possible upon them.
- **Semantic Level:** The semantic level describes the functions performed by the system. This corresponds to a description of the functional specifications of the system, but it does not address how the user will invoke the functions.
- **Syntactic Level:** The syntactic level describes the input and output sequences required to invoke the described functions. A related method is the syntactic-semantic object-action model, which separates the task and computer concepts (i.e., the semantics in the previous paragraph) from the task syntax.
- **Lexical Level:** The lexical level determines how raw hardware operations are transformed into inputs and outputs.

HCI improves user-computer experiences by making machines more accessible and responsive to the user's needs. HCI is important because it would be necessary for goods to be more effective, healthy, and useful. It will make the user's experience more pleasurable in the long run. As a result, having someone with HCI skills involved in all phases of any product or device creation is critical. HCI is often crucial to prevent goods or programmes from failing entirely.

The focus of HCI is as follows:

- It focuses on user-centred design now-a-days
- High-cost e-transformation investments
- It helps users in interaction with the computer in effective manner
- Users do not want to use bad interfaces

System users often judge a system by its interface rather than its functionality. A poorly designed interface can cause a user to make catastrophic errors. Poor user interface design is the reason why so many software systems are never used.

Check Your Progress

5. List any two benefits of a good design.
6. State the importance of a good user interface.
7. What is a conceptual level?
8. Define the term lexical level.

1.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

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1. The Human Computer Interface (HCI) can be described as the point of communication between the human user and the computer.
2. The flow of information between the human and computer is defined as the loop of interaction.
3. Computer Human Interaction (CHI) is another term for Human Computer Interaction (HCI).
4. Below are the components of HCI:
   - User
   - The Machine
   - Interaction
5. The benefits of a good design are as follows:
   - Screens looks very friendly and less messy.
   - Help in understanding the overall design and so easy to start communication without wasting much time.
6. User Interface (UI) design is the link between users and application which includes the basic design elements. These design elements need to be present to help the end user to navigate through the application.
7. The conceptual level describes the basic entities underlying the user's view of the system and the actions possible upon them.
8. The lexical level determines how raw hardware operations are transformed into inputs and outputs.

1.7 SUMMARY

- The Human Computer Interface (HCI) can be described as the point of communication between the human user and the computer.
- The flow of information between the human and computer is defined as the loop of interaction.
- Human Computer Interaction (HCI) is the study of how people communicate with computers and to what extent computers are developed for effective human interaction.
- Interface is something that we want it look good and friendly to the end user. The poorly designed interfaces can lead to serious implications and will not be able to engage the end user for the longer period and will reduce the users in future.

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- Humans and robots have distinct characteristics. Despite this, HCI takes every effort to ensure that they get along and communicate effectively.
- The aim of HCI is to create systems that are both useful and safe, as well as functional.
- Visions of what researchers in the field seek to achieve might vary. When pursuing a cognitivist perspective, researchers of HCI may seek to align computer interfaces with the mental model that humans have of their activities.
- Researchers in HCI are interested in developing design methodologies, experimenting with devices, prototyping software, and hardware systems, exploring interaction paradigms, and developing models and theories of interaction.
- The most significant benefit of implementing human computer interaction is the creation of more user-friendly applications.
- A strong user experience will help in attracting and retaining customers. The more customer acquisition will help in building the trust and so will be helpful in retaining the for longer period.
- A well-designed application or Website work for end users for longer period. It helps in optimizing the resources . the optimizing resource utilization then help in reducing the time and cost of development.
- HCI helps in development of effective, user friendly and easy to use interface. This help in increasing the productivity and so also help in increasing the organization's business.
- Human computer interaction helps in reducing the errors hence helps in the smoother workflow.
- Human Computer Interaction (HCI) principles not only important for the end user, but also is an extremely high priority for software development companies.
- Human Computer Interaction (HCI) emerged in the early 1980s, initially as a specialty area in computer science embracing cognitive science and human factors engineering.
- For three decades, HCI has grown slowly and gradually , attracting people from a wide range of disciplines, and encompassing a wide range of concepts and methodologies.
- Human Computer Interaction (HCI) is a research and practice area that first arose in the late 1970s and early 1980s as a branch of computer science.
- Mental modelling and human factors engineering were the driving factors in software development. This era was all about usability, and we learned a great deal about what people could and could not do while completing tasks on a computer.

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- As computers became communication tools, mental models could no longer explain the broader context of computer use.
- Email gained popularity during this time, which meant that people were not just interacting with computers — they were interacting with *each other* through computers.
- A holistic approach to design emerges as well, emphasizing complex interactions across people, spaces, and technologies. Qualities of pleasure, enjoyment, play, and exploration become central to design.
- The broad project of cognitive science, which incorporated cognitive psychology, artificial intelligence, linguistics, cognitive anthropology, and the philosophy of mind, had formed at the end of the 1970s.
- The Graphical User Interface (GUI) is a user interface that is designed to make it easier for computer users to understand.
- Mobile phones, PDA (Personal Development Assistance) and Smart Phones are ruling the present world. They offer a wide range of services to the people, such as sms, mms, multimedia, games, email, Internet, chatting, video conference, GPS, etc.
- Quantitative usability specifics, such as the number of users performing the task, the time to complete the task, and the number of errors made during the task are determined.
- Various strategies delineating methods for human–PC interaction design have developed since the ascent of the field during the 1980s.
- Utilized in HCI to characterize and consider the setting where human cooperation with PCs occurs.
- Action hypothesis gives a structure for reasoning about activities in these specific circumstances and illuminates design of interactions from an action-driven perspective.
- Client Focused Structure (CFS) is a cutting edge, broadly rehearsed plan theory established on the possibility that clients must become the overwhelming focus in the plan of any PC framework.
- Clients, architects, and specialized experts cooperate to determine the requirements and restrictions of the client and make a framework to support these components.
- A technique for building innovation that accounts for the individuals who utilize the design straightforwardly, and just as well for those who the design influences, either directly or indirectly.
- A screen's layout and appearance affect a person in a different of ways, so it is important to give importance to the good design.
- A well-designed interface and screen are especially important for the users. It is their space to work with simple and complex tasks.

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- The structure and appearance of a screen have several effects on an individual user.
- An interface can be nothing more than a person's extension. This means that the system and its software must consider a person's abilities and adapt to his or her unique specifications.
- A good user interface is critical to good user experience. If the interface does not allow people to easily use the Website or app, they will not use the product or they will overwhelm tech support with costs, ballooning costs.
- Clarity inspires confidence and encourages continued use. One hundred uncluttered screens are superior to one cluttered screen.
- Interaction between humans and our world is facilitated by interfaces. They can help us explain, illuminate, allow, display relationships, bring us together, separate us, manage expectations, and provide access to services.
- User Interface (UI) design is the link between users and application which includes the basic design elements. These design elements need to be present to help the end user to navigate through the application.
- A user interface is that portion of an interactive computer system that communicates with the user.
- A good user interface cannot be added to a system after it has been developed; it must be designed from the start. A well-designed user interface can significantly reduce training time and improve performance.
- The design of a user interface can have a significant impact on training time, performance speed, mistake rates, user happiness, and the user's long-term retention of operations knowledge.
- Design of a user interface begins with task analysis—an understanding of the user's underlying tasks and the problem domain. The user interface should be designed in terms of the user's terminology and conception of his or her job, rather than the programmer's.
- The conceptual level describes the basic entities underlying the user's view of the system and the actions possible upon them.
- The semantic level describes the functions performed by the system. This corresponds to a description of the functional specifications of the system, but it does not address how the user will invoke the functions.
- The syntactic level describes the input and output sequences required to invoke the described functions.
- The lexical level determines how raw hardware operations are transformed into inputs and outputs.

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1.8 KEY WORDS

- **Visual based:** The visual-based human computer interaction is probably the most widespread area in Human Computer Interaction (HCI) research.
- **Audio based:** The audio-based interaction between a computer and a human is another important area of HCI systems.
- **Input flow:** The flow of information that begins in the task environment, when the user has some tasks that requires using their computer.
- **Human Computer Interaction (HCI):** It is the study of how people communicate with computers and to what extent computers are developed for effective human interaction.
- **Feedback:** Loops through the interface that evaluate, moderate, and confirm processes as they pass from the human through the interface to the computer and back.
- **Fit:** This is the match between the computer design, the user, and the task to optimize the human resources needed to accomplish the task.
- **Activity theory:** Utilized in HCI to characterize and consider the setting where human cooperation with PCs occurs.
- **Value delicate design:** A technique for building innovation that accounts for the individuals who utilize the design straightforwardly, and just as well for those who the design influences, either directly or indirectly.
- **The conceptual level:** It describes the basic entities underlying the user's view of the system and the actions possible upon them.
- **The semantic level:** It describes the functions performed by the system. This corresponds to a description of the functional specifications of the system, but it does not address how the user will invoke the functions.
- **The syntactic level:** It describes the input and output sequences required to invoke the described functions.
- **The lexical level:** It determines how raw hardware operations are transformed into inputs and outputs.

1.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Why good design is important for any application?
2. What are the various goals of a Human Computer Interaction (HCI)?
3. Define few benefits of good design.

4. Explain various principles of User Interface (UI) design.
5. List the various applications of HCI.
6. Name the various design levels of a User Interface (UI).

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Long-Answer Questions

1. What is Human Computer Interface (HCI)? Explain in brief with the help of suitable examples.
2. Describe the various goals to use human computer interface giving appropriate examples.
3. Elaborate on the history of Human Computer Interaction (HCI) giving examples of all its decades.
4. Discuss the various benefits of a good design giving suitable examples.
5. Discuss in brief about importance of User Interface (UI).
6. Briefly discuss the various designs of User Interface (UI).

1.10 FURTHER READINGS

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UNIT 2 INTERACTION DEVICES

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Structure

2.0 Introduction
2.1 Objectives
2.2 Interaction Devices
2.3 Image Display
  2.3.1 Basic Types and Image Files
  2.3.2 JPEG Compression Scheme
  2.3.3 Image Processing
  2.3.4 3D Images and Operations
  2.3.5 Image Editing and Modeling Softwares
2.4 Video Display
  2.4.1 Video Display Devices
  2.4.2 Raster Scan Display
  2.4.3 Random Scan Display
  2.4.4 Liquid Crystal Display (LCD)
  2.4.5 Direct View Storage Tube
2.5 Morphing
2.6 Device Drivers
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2.7 Speech Recognition
  2.7.1 Techniques of Speech Recognition
  2.7.2 Applications of Speech Recognition
2.8 Handwriting Recognition
2.9 Speech Generation
2.10 Answers to Check Your Progress Questions
2.11 Summary
2.12 Key Words
2.13 Self Assessment Questions and Exercises
2.14 Further Readings

2.0 INTRODUCTION

Computers have an input-output subsystem, referred to as I/O subsystem, which provides an efficient mode of communication between the central system and the outside world. Programs and data must be entered into the computer memory for processing, and results obtained from computations must be displayed or recorded for the user's benefit. This can be explained with a common scenario where the average marks of a student need to be calculated based on the marks obtained in various subjects. The marks would typically be available in the form of a document containing the student's name, roll number and marks scored in each subject. A multimedia projector is an output device which is used to project information from the computer onto a large screen so that it can be viewed by a large group of people. Prior to this, the standard mode of making presentations was to make

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transparencies and project them using an overhead projector. This was a tedious and time-consuming activity, since for every change in the subject matter a new transparency had to be prepared. An image is an artefact that depicts visual perception, such as a photograph or other two-dimensional picture that resembles a subject—usually a physical object—and thus provides a depiction of it. In the context of signal processing, an image is a distributed amplitude of color(s). A pictorial script is a writing system that employs images as symbols for various semantic entities, rather than the abstract signs used by alphabets. Images may be two-dimensional, such as a photograph or screen display, or three-dimensional, such as a statue or hologram. They may be captured by optical devices, such as cameras, mirrors, lenses, telescopes, microscopes, etc., and natural objects and phenomena, such as the human eye or water.

Graphics capabilities for both two-dimensional and three-dimensional applications are now common in general-purpose computer applications, including many handheld tools like calculators. Graphics users can use a wide variety of interactive input devices and graphics software packages with personal computers. They can choose from several complicated special-purpose graphics hardware systems (like track ball and plotters) and technologies for higher quality applications. In this unit, you will study about the interaction devices, image display, video display, device drivers, speech recognition, handwriting recognition and speech generator.

2.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of interaction devices
- Interpret the types of image display
- Discuss the various input devices
- Understand the importance of output devices
- Learn about the display devices
- Know about the 3D images and operations
- Discuss about video display
- Understand about the device drivers
- Know about speech recognition
- Learn about handwriting recognition
- Discuss about speech generator

2.2 INTERACTION DEVICES

The computer system is a dumb and a useless machine if it is not capable of communicating with the outside world. It is very important for a computer system to have the ability to communicate with the outside world, i.e., receive and send data and information.

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Computers have an input-output subsystem, referred to as I/O subsystem, which provides an efficient mode of communication between the central system and the outside world. Programs and data must be entered into the computer memory for processing, and results obtained from computations must be displayed or recorded for the user's benefit. This can be explained with a very common scenario where the average marks of a student need to be calculated based on the marks obtained in various subjects. The marks would typically be available in the form of a document containing the student's name, roll number and marks scored in each subject. This data must first be stored in the computer's memory after converting it into machine-readable form. The data will then be processed (average marks calculated) and sent from the memory to the output unit, which will present the data in a form that can be read by users.

The I/O devices that provide a means of communication between the computer and the outside world are known as peripheral devices. This is because they surround the CPU and the memory of a computer system. While input devices are used to enter data from the outside world into the primary storage, output devices are used to provide the processed results from primary storage to users.

Input Devices

Input devices are used to transfer user data and instructions to the computer. The most commonly used input devices can be classified into the following categories:

- Keyboard devices (general and special purpose, key-to-tape, key-to-disk, key-to-diskette)
- Point-and-draw devices (mouse, trackball, joystick, light pen, touch screen)
- Scanning devices (optical mark recognition, magnetic ink character recognition, optical barcode reader, digitizer, electronic-card reader)
- Voice recognition devices
- Vision-input devices (webcam, video camera)

Keyboard Devices

Keyboard devices allow input into the computer system by pressing a set of keys mounted on a board, connected to the computer system. Keyboard devices are typically classified as general-purpose keyboards and special-purpose keyboards.

General-purpose keyboard

The most familiar means of entering information into a computer is through a typewriter-like keyboard that allows a person to enter alphanumeric information directly.

The most popular keyboard used today is the 101-key with a traditional QWERTY layout, with an alphanumeric keypad, 12 function keys, a variety of special function keys, numeric keypad, and dedicated cursor control keys. It is so called because the arrangement of its alphanumeric keys in the upper-left row (as seen in the Figure 2.1).

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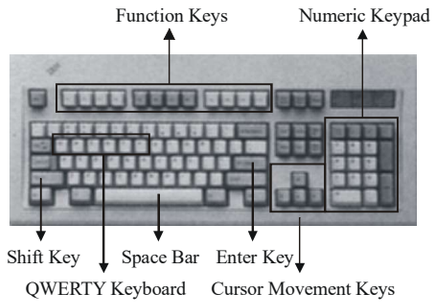

Fig. 2.1 *QWERTY Keyboard Layout*

- **Alphanumeric keypad:** This contains keys for the English alphabets, 0 to 9 numbers, special characters like * + – / [ ], etc.
- **12 Function keys:** These are keys labelled F1, F2 ... F12 and are a set of user- programmable function keys. The actual function assigned to a function key differs from one software package to another. These keys are also called soft keys since their functionality can be defined by the software.
- **Special function keys:** Special functions are assigned to each of these keys. The enter key, for example, is used to send the keyed-in data into the memory. Other special keys include:
    - o *Shift* (used to enter capital letters or special characters defined above the number keys)
    - o *Spacebar* (used to enter a space at the cursor location)
    - o *Ctrl* (used in conjunction with other keys to provide added functionality on the keyboard)
    - o *Alt* (like Ctrl, used to expand the functionality of the keyboard)
    - o *Tab* (used to move the cursor to the next tab position defined)
    - o *Backspace* (used to move the cursor a position to the left and also delete the character in that position)
    - o *Caps Lock* (to toggle between the capital letter lock feature – when 'on', it locks the keypad for capital letters input)
    - o *Num Lock* (to toggle the number lock feature – when 'on', it inputs numbers when you press the numbers on the numeric keypad)
    - o *Insert* (used to toggle between the insert and overwrite mode during data entry – when 'on', entered text is inserted at the cursor location)
    - o *Delete* (used to delete the character at the cursor location)
    - o *Home* (used to move the cursor to the beginning of the work area which could be the line, screen or document depending on the software being used)
    - o *End* (used to move the cursor to the end of the work area)

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- o *Page Up* (used to display the previous page of the document being currently viewed on screen)
- n *Page Down* (used to view the next page of the document being currently viewed on screen)
- n *Escape* (usually used to negate the current command)
- n *Print Screen* (used to print what is being currently displayed on the screen)

- **Numeric keypad:** This consists of keys with numbers (0 to 9) and mathematical operators (+ – * /) defined on them. It is usually located on the right side of the keyboard and supports quick entry of numerical data.
- **Cursor control keys:** They are defined by the arrow keys used to move the cursor in the direction indicated by the arrow (top, down, left, right).

Another popular key arrangement, called Dvorak system, was designed for easy learning and use. It was designed with the most common consonants in one part and all the vowels on the other part of the middle row of the keyboard. This key arrangement made the users use alternate keystrokes back and forth between both the hands. This keyboard was never been commonly used.

Special-purpose keyboard

These are standalone data entry systems used for computers deployed for specific applications. These typically have special-purpose keyboards to enable faster data entry. A very typical example of such keyboards can be seen at the Automatic Teller Machines or the ATMs where the keyboard is required for limited functionality (support for some financial transactions) by the customers. Point-of-sale or POS terminals at fast food joints and Air/Railway reservation counters are some other examples of special-purpose keyboards. These keyboards are specifically designed for special types of applications only.

Key-to-tape, key-to-disk, key-to-diskette

These are individual standalone workstations used for data entry only. These processor-based workstations normally have a keyboard and a small monitor. The function of the processor is to check the accuracy of the data when it is being entered.

The screen displays data as it is being entered. These facilities are very useful and desirable during mass data entry and are therefore becoming very popular in data processing centres.

Point-and-Draw Devices

The keyboard facilitates input of data in text form only. While working with display-based packages, we usually point to a display area and select an option from the screen (fundamentals of GUI applications). For such cases, the sheer user-

friendliness of input devices that can rapidly point to a particular option displayed on screen and support its selection resulted in the advent of various point-and-draw devices.

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Mouse

A mouse is a small input device used to move the cursor on a computer screen to give instructions to the computer and to run programs and applications. It can be used to select menu commands, move icons, size windows, start programs, close windows, etc. Initially, the mouse was a widely used input device for the Apple computer and was a regular device of the Apple Macintosh. Nowadays, the mouse is the most important device in the functioning of a Graphical User Interface (GUI) of almost all computer systems.

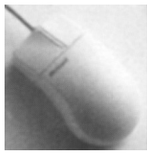

Fig. 2.2 *Mouse*

You can click a mouse button, i.e., press and release the left mouse button, to select an item. You can right click, i.e., press and release the right mouse button to display a list of commands. You can double click, i.e., quickly press the left mouse button twice without any time gap between the press of the buttons, to open a program or a document. You can also drag and drop, i.e., place the cursor over an item on the screen and than press and hold down the left mouse button. Holding down the button, move the cursor to where you want to place the item and then release the button.

Touch screen

A touch screen is probably one of the simplest and most intuitive of all input devices. It uses optical sensors in or near the computer screen that can detect the touch of a finger on the screen. Once the user touches a particular screen position, sensors communicate the position to the computer. This is then interpreted by the computer to understand the user's choice for input. The most common usage of touch screens is in information kiosks where users can receive information at the touch of a screen. These devices are becoming increasingly popular today.

Fig. 2.3 *Touch Screen*

NOTES

Touch pads

A touch pad is a touch sensitive input device which takes user input to control the onscreen pointer and perform other functions similar to that of a mouse. Instead of having an external peripheral device such as a mouse, the touch pad enables the user to interact with the device through the use of a single or multiple fingers being dragged across relative positions on a sensitive pad. They are mostly found in notebooks and laptops where convenience, portability and space are the prime design concerns. Touch pads are pressure and touch sensitive. They use finger drag and tapping combinations to perform multiple control operations. A user, for instance, can also perform the scroll function of a mouse by sliding a finger in-between certain points, usually the extreme top and bottom corners on the right side of the pad. Their user interface is much more convenient to use and puts less strain on wrist and hand, which is the most common side effect of using computers with mouse over a long period of time. The functionality of a touch pad is not limited by the manufacturer's user interface. They can be user programmed to recognize a combination of finger and tap moments to perform new actions as an input device. Touch pads have shown steady growth in market demand and user acceptability over all phases of their development cycles. Their growth is further expected to continue in the same way as the demand for touch-sensitive portable devices with more functionality and better appearance is on the rise.

Fig. 2.4 *Touch Pad*

Light pen

The light pen is a small input device used to select and display objects on a screen. It functions with a light sensor and has a lens on the tip of a pen-shaped device. The light receptor is activated by pointing the light pen towards the display screen and it then locates the position of the pen with the help of a scanning beam application to directly draw on screen.

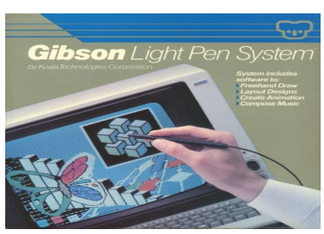

Fig. 2.5 *Light Pen*

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Trackball

The trackball is a pointing device that is much like an inverted mouse. It consists of a ball inset in a small external box or adjacent to, and in the same unit, as the keyboard of some portable computers.

It is more convenient and requires much less space than the mouse since here the whole device is not moved (as in the case of a mouse). Trackball comes in various shapes but supports the same functionality. Typical shapes used are a ball, a square and a button (typically seen in laptops).

Fig. 2.6 *Trackball*

Joystick

The joystick is a vertical stick that moves the graphic cursor in the direction the stick is moved. It consists of a spherical ball, which moves within a socket and has a stick mounted on it. The user moves the ball with the help of the stick that can be moved left or right, forward or backward, to move and position the cursor in the desired location. Joysticks typically have a button on top that is used to select the option pointed by the cursor.

Video games, training simulators and control panels of robots are some common uses of a joystick.

Fig. 2.7 *Joystick*

Scanning Devices

Scanning devices are input devices used for direct data entry from the source document into the computer system. With the help of the scanner you can capture your images and documents and convert it into digital formats for easy storage on your computer. The scanner comprises of two major components, the first component lights up the page in order to capture the optical image and the second component converts that captured image into a digital format for viewing and storing it on your computer system.

NOTES

There are two types of scanners, CONTACT and LASER. Both illuminate the image first to calculate the reflected light and determine the value of the captured image. Hand-held contact scanners make contact as they are brushed over the printed matter to be read. Laser-based scanners are more versatile and can read data passed near the scanning area.

Fig. 2.8 *Hand-held Scanner*

Hand-held scanners are used where the information to be scanned or the volume of documents to be scanned is very low. They are much cheaper as compared to the flat-bed scanners. Capturing information using scanners reduces the possibility of human error typically seen during large data entry. The reduction in human intervention improves the accuracy of data and provides for timeliness of the information processed.

Fig. 2.9 *Flat-bed Scanner*

Source data automation is the recent development for data input technologies. Source data automation does not require any manual data entry; rather it captures the data as a derivative of the routine business activity.

Optical Mark Recognition (OMR)

The OMR devices can scan marks from a computer-readable paper. Such devices are used by universities and institutes to mark test sheets where the candidate selects and marks the correct answer from multiple choices given on a special sheet of paper. These marksheets are not required to be evaluated manually as they are fed in the OMR and the data is then transferred to the computer system for further evaluation.

The actual technique used by an OMR device once again involves focussing a light on the page being scanned, thereby detecting the reflected light pattern for the marks. Pencil marks made by the user reflect the light determining which responses are marked.

Answer Sheet 1. a b c d 2. a b c d 3. a b c d 4. a b c d

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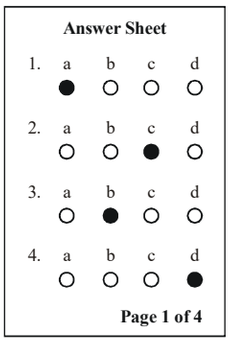

Fig. 2.10 *Sheet Read by an OMR Device*

Magnetic Ink Character Recognition (MICR)

Magnetic ink character recognition is like an optical mark recognition device and is used only in the banking industry. MICR devices scan cheque numbers directly from the cheque leaflets and then automatically feed them in the computer systems for further use, doing the job quickly, accurately and efficiently.

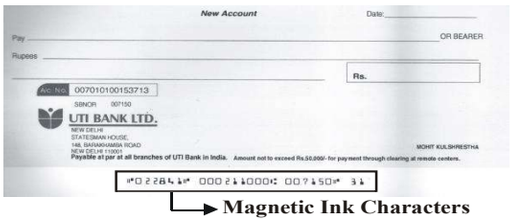

Fig. 2.11 *A Bank Cheque using MICR Technology*

Banks using MICR technology print cheque books on special types of paper. The necessary details of the bank (like the bank's identification code, relevant account number and cheque number) are pre-printed on the cheques using an ink that contains iron oxide particles that can be magnetized.

MICR readers are used to read and sort cheques and deposits. An MICR reader-sorter reads the data on the cheques and sorts the cheques for distribution to other banks and customers or for further processing.

Optical Bar Code Reader (OBR)

Data coded in the form of small vertical lines forms the basis of bar coding. Alphanumeric data is represented using adjacent vertical lines called bar codes. These are of varying widths and the spacing between them are used to uniquely identify books, merchandise in stores, postal packages, etc. The following figure shows a bar code used on a book for its unique identification.

NOTES

Fig. 2.12(a) *Bar code Example* ***Fig. 2.12(b)*** *Bar code Reader*

A bar code reader uses laser beam technology. The laser beam is moved across the pattern of bars in a bar code. These bars reflect the beam in different ways. The reflected beam is then sensed by a light-sensitive detector, which then converts the light patterns into electrical pulses, thereby transmitting them to logic circuits for further conversion to alphanumeric value. Bar code devices are available as hand-held devices.

Digitizer

Digitizers are used to convert drawings or pictures and maps into a digital format for storage into the computer. A digitizer consists of a digitizing or graphics tablet, which is a pressure-sensitive tablet, and a pen with the same X and Y coordinates as on the screen. Some digitizing tablets also use a crosshair device instead of a pen. The movement of the pen or crosshair is reproduced simultaneously on the display screen. When the pen is moved on the tablet, the cursor on the computer screen moves simultaneously to the corresponding position on the screen (X and Y coordinates). This allows the user to draw sketches directly or input existing sketched drawings easily. Digitizers are commonly used by architects and engineers as a tool for Computer-Aided Designing (CAD).

Fig. 2.13 *Digitizing Tablet*

Electronic-card Reader

Card readers are devices that also allow direct data input into a computer system. The electronic-card reader is connected to a computer system and reads the data encoded on an electronic card and transfers it to the computer system for further processing. Electronic cards are plastic cards with data encoded on them and meant for a specific application. Typical examples of electronic cards are the plastic cards issued by banks to their customers for use in ATMs. Electronic cards are also used by many organizations for controlling access of various types of employees to physically secured areas.

NOTES

Fig. 2.14 *Access Card Security System*

Depending on the manner in which the data is encoded, electronic cards may be either magnetic strip cards or smart cards. Magnetic strip cards have a magnetic strip on the back of the card. Data stored on magnetic strips cannot be read with the naked eye, a useful way to maintain confidential data. Smart cards, going a stage further, have a built-in microprocessor chip where data can be permanently stored. They also possess some processing capability making them suitable for a variety of applications. To gain access, for example, an employee inserts a card or badge in the reader. This device reads and checks the authorization code before permitting the individual to enter a secured area. Since smart cards can hold more information as compared to magnetic strip cards, they are gaining popularity.

Voice Recognition Devices

One of the most exciting areas of research involves the recognizing of an individual human voice as the basis of input to the computer system. Eliminating the keying in of data, basic commands can very easily be given, facilitating quick operation. Voice recognition devices consist of a microphone attached to the computer system. A user speaks into the microphone to input data. The spoken words are then converted into electrical signals (this is in the analog form). A digital-to-analog converter then converts the analog form to digital form (0s and 1s) that can be interpreted by the computer. The digitized version is then matched with the existing pre-created dictionary to perform the necessary action. Voice recognition devices have limited usage today because they have several problems. Not only do they require the ability to recognize who is speaking, but also what is being said (the message). This difficulty arises primarily because people speak with different accents and different tones and pitches. The computer requires a large vocabulary to be able to interpret what is being said. Today's voice recognition systems are therefore successful in a limited domain. They are limited to accepting words and tasks within a limited scope of operation and can handle only small quantities of data.

Most speech-recognition systems are speaker-dependent, that is, they respond to the unique speech of a particular individual, a feature not necessarily inconvenient, but limiting generalized applications. It therefore requires creating a database of words for each person using the system.

Vision-Input Devices

Vision input devices allow data input in the form of images. It usually consists of a digital camera, which focuses on the object whose picture is to be taken. The camera creates the image of the object in digital format, which can then be stored within the computer.

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As the speech recognition system digitizes the voice input, this system similarly compares the digitized images to be interpreted to the pre-recorded digitized images of the database of your computer system. Once it finds the right match it sends it for further processing or pre-defined action.

Video input or capture is the recording and storing of full-motion video recordings on your computer system's storage device. High-end video accelerator and capture cards are required to capture and view good quality video recordings on your computer. File compression of the recorded video file is very important for file storage, since the video files captured are of high quality and may take up one gigabyte of disk space. The most popular standard used for compression is the motion pictures expert group (MPEG). Webcams and video cameras are most commonly used to input visual data.

Web Camera

A Web camera is a video capturing device attached to the computer system, mostly using a USB port used for video conferencing, video Security, as a control input device and also in gaming .

Output Devices

An output device is an electromechanical device that accepts data from the computer and translates it into a form that can be understood by the outside world. The processed data, stored in the memory of the computer, is sent to an output unit, which then transforms the internal representation of data into a form that can be read by the users.

Normally, the output is produced on a display unit like a computer monitor or can be printed through a printer on paper. At times speech outputs and mechanical outputs are also used for some specific applications.

Output produced on display units or speech output that cannot be touched is referred to as softcopy output while output produced on paper or material that can be touched is known as hardcopy output. A wide range of output devices are available today and can be broadly classified as follows:

- Display devices (monitors, multimedia projectors)
- Speakers
- Printers (dot matrix, inkjet, laser)
- Plotters (flatbed, drum)

NOTES

Display Devices

It is almost impossible to even think of using a computer system without a display device. A display device is the most essential peripheral of a computer system. Initially, alphanumeric display terminals were used that formed a 7×5 or 9×7 array of dots to display text characters only. As a result of the increasing demand and use of graphics and GUIs, graphic display units were introduced. These graphic display units are based on series of dots known as pixels used to display images. Every single dot displayed on the screen can be addressed uniquely and directly.

Owing to the fact that each dot can be addressed as a separate unit, it provides greater flexibility for drawing pictures. Display screen technology may be of the following categories:

Cathode Ray Tube (CRT): The CRT consist of an electron gun with an electron beam controlled with electromagnetic fields and a phosphate-coated glass display screen structured into a grid of small dots known as pixels. The image is created with the electron beam produced by the electron gun, which is thrown on the phosphor coat displayed by the electromagnetic field.

Liquid Crystal Display (LCD): Liquid Crystal Display (LCD) was first introduced in the 1970s in digital clocks and watches, and is now widely being used in computer display units. The Cathode Ray Tube (CRT) was replaced with the Liquid Crystal Display (LCD) making it slimmer and more compact. But the image quality and the image colour capability got comparatively poorer.

The main advantage of LCD is its low energy consumption. It finds its most common usage in portable devices where size and energy consumption are of main importance.

Projection display: Projection display technology is characterized by replacing the personal size screen with large screens upon which the images are projected. It is attached to the computer system and the magnified display of the computer system is projected on a large screen.

Monitors: Monitors use a Cathode Ray Tube (CRT) to display information. It resembles a television screen and is similar to it in other respects.

Fig. 2.15 *CRT Monitor*

The monitor is typically associated with a keyboard for manual input of characters. The screen displays information as it is keyed in, enabling a visual check of the input before it is transferred to the computer. It is also used to display the output from the computer and hence serves as both an input and an output device.

This is the most commonly used input/output device today and is also known as a soft copy terminal. A printing device is usually required to provide a hard copy of the output.

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Multimedia projectors

A multimedia projector is an output device which is used to project information from the computer onto a large screen so that it can be viewed by a large group of people. Prior to this, the standard mode of making presentations was to make transparencies and project them using an overhead projector. This was a tedious and time-consuming activity, since for every change in the subject matter a new transparency had to be prepared. And of course, since electronic cut, copy and paste was not possible this, meant additional work.

A multimedia projector can directly be plugged into a computer system and the information projected on a large screen thereby making it possible to present information to a large audience. The presenter can also use a pointer to emphasize specific areas of interest in the presentation.

LCD flat screens connected to the computer systems for projecting the LCD image using an overhead multimedia projector are widely used today.

Owing to its convenience and applicability, multimedia projectors are increasingly becoming popular in seminars, presentations and classrooms.

Speakers

Used to produce music or speech from programs, a speaker port (a port is a connector in your computer wherein you can connect an external device) allows connection of a speaker to a computer. Speakers can be built into the computer or can be attached separately.

Printers

Printers are used for creating paper output. There is a huge range of commercially available printers today (estimated to be 1500 different types). These printers can be classified into categories based on:

- Printing technology
- Printing speed
- Printing quality

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Printing technology: Printers can be classified as impact or non-impact printers, based on the technology they use for producing output. Impact printers work on the mechanism similar to a manual typewriter where the printer head strikes on the paper and leaves the impression through an inked ribbon. Dot matrix printers and character printers fall under this category. Non-impact printers use chemicals, inks, toners, heat or electric signals to print on the paper and they do not physically touch the paper while printing.

Printing speed: This refers to the number of characters printed in a unit of time. Based on speed, these may be classified as character printer (prints one character at a time), line printers (prints one line at a time), and page printers (print the entire page at a time). Printer speeds are therefore measured in terms of characters-per-second or cps for a character printer, lines-per-minute or lpm for a line printer, and pages-per-minute or ppm for a page printer.

Printing quality: Is determined by the resolution of printing and is characterized by the number of dots that can be printed per linear inch, horizontally or vertically. It is measured in terms of dots-per-inch or dpi. Printers can be classified as near-letter-quality or NLQ, letter-quality or LQ, near-typeset-quality or NTQ and typeset-quality or TQ, based on their printing quality. NLQ printers have resolutions of about 300 dpi, LQ of about 600 dpi, NTQ of about 1200 dpi and TQ of about 2000 dpi. NLQ and LQ printers are used for ordinary printing in day-to-day activities, while NTQ and TQ printers are used to produce top-quality printing, typically required in the publishing industry.

Types of Printers

Dot matrix

Dot matrix printers are the most widely used impact printers in personal computing. These printers use a print head consisting of a series of small metal pins that strike on a paper through an inked ribbon, leaving an impression on the paper through the ink transferred. Characters thus produced are in a matrix format. The shape of each character, i.e., the dot pattern, is obtained from information held electronically.

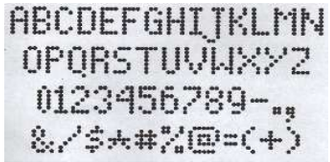

Fig. 2.16(a) *Characters formed using Dots*

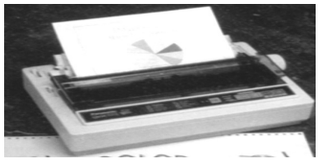

Fig. 2.16(b) *Dot Matrix Printer*

The speed, versatility and ruggedness, combined with low cost, tend to make such printers particularly attractive in the personal computer market. Typical printing speeds in case of dot matrix printers range between 40 - 1000 characters per second (cps). In spite of all theses features in dot matrix printer technology, the low print quality gives it a major disadvantage

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Inkjet

Inkjet printers are based on the use of a series of nozzles for propelling droplets of printing ink directly on almost any size of paper. They, therefore, fall under the category of non-impact printers. The print head of an inkjet printer consists of a number of tiny nozzles that can be selectively heated up in a few microseconds by an IC register. When this happens, the ink near it vaporizes and is ejected through the nozzle to make a dot on the paper placed in front of the print head. The character is printed by selectively heating the appropriate set of nozzles as the print head moves horizontally.

Fig. 2.17 *Inkjet Printer*

Laser

Laser printers work on the same printing technology as photocopiers, using static electricity and heat to print with a high quality powder substance known as toner.

Laser printers are capable of converting computer output into print, page by page. Since characters are formed by very tiny ink particles, they can produce very high quality images (text and graphics). They generally offer a wide variety of character fonts, and are silent and fast in use. Laser printers are faster in printing speed than other printers discussed above. Laser printers can print from 10 pages to 100 pages per minute, depending upon the make/model. Laser is high quality, high speed, high volume and non-impact technology that works on almost any kind of paper. Even though this technology is more expensive than inkjet printers, it is preferred because of its unmatched features, such as high quality, high-speed printing and noiseless and easy-to-use operations.

Fig. 2.18 *Laser Printer*

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Plotters

Plotters are used to make line illustrations on paper. They are capable of producing charts, drawings, graphics, maps and so on. A plotter is much like a printer but is designed to print graphs instead of alphanumeric characters. Based on the technology used, there are mainly two type of plotters: pen plotters or electrostatic plotters. Pen plotters, also known as flatbed plotters, draw images with multicolored pens attached to a mechanical arm. Electrostatic plotters, also known as drum plotters, work on the same technology as laser printers.

Flatbed plotters and drum are the most commonly used plotters.

Flatbed plotters

Flatbed plotters have a flat base like a drawing board on which the paper is laid (as shown in Figure 2.19(a)). One or more arms, each of them carrying an ink pen, moves across the paper to draw. The arm movement is controlled by a microprocessor (chip). The arm can move in two directions, one parallel to the plotter and the other perpendicular to it (called the *x* and *y* directions). With this kind of movement, it can move very precisely to any point on the paper placed below.

The computer sends the commands to the plotter which are translated into *x* and *y* movements. The arm moves in very small steps to produce continuous and smooth graphics.

The size of the plot in a flatbed plotter is limited only by the size of the plotter's bed.

The advantage of flatbed plotters is that the user can easily control the graphics. He can manually pick up the arm anytime during the production of graphics and place it on any position on the paper to alter the position of graphics to his choice.

The disadvantage here is that flatbed plotters occupy a large amount of space.

Drum plotters

Drum Plotters move the paper with the help of a drum revolver during printing (as shown in Figure 2.19 (b)). The arm carrying a pen moves only in one direction, perpendicular to the direction of the motion of the paper. It means that while printing, the plotter pens print on one axis of the paper and the cylindrical drum moves the paper on the other axis. With this printing technology, the plotter has an advantage to print on unlimited length of paper but on a limited width. Drum plotters are compact and lightweight compared to flatbed plotters. This is one of the advantages of such plotters.

The disadvantage of drum plotters, however, is that the user cannot freely control the graphics when they are being created. Plotters are more expensive

when compared to printers. Typical application areas for plotters include Computer-Aided Engineering (CAE) applications, such as Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM), architectural drawing and map drawing.

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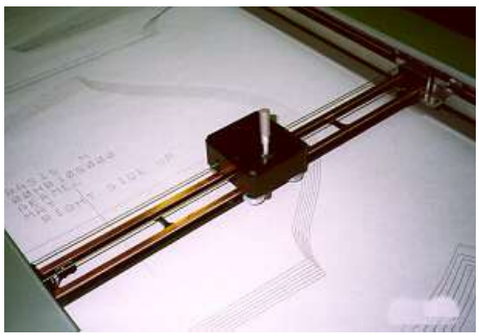

Fig. 2.19(a) *Top view of a flatbed plotter*

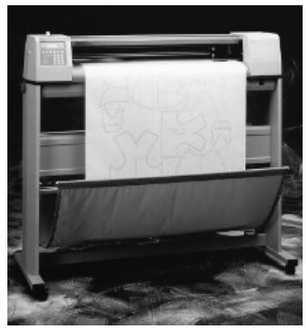

Fig. 2.19(b) *Drum plotter*

2.3 IMAGE DISPLAY

An image is an artefact that depicts visual perception, such as a photograph or other two-dimensional picture that resembles a subject—usually a physical object—and thus provides a depiction of it. In the context of signal processing, an image is a distributed amplitude of color(s). A pictorial script is a writing system that employs images as symbols for various semantic entities, rather than the abstract signs used by alphabets. Images may be two-dimensional, such as a photograph or screen display, or three-dimensional, such as a statue or hologram. They may be captured by optical devices, such as cameras, mirrors, lenses, telescopes, microscopes, etc., and natural objects and phenomena, such as the human eye or water.

The word 'Image' is also used in the broader sense of any two-dimensional figure, such as a map, a graph, a pie chart, a painting or a banner. In this wider sense, images can also be rendered manually, such as by drawing, the art of painting, carving, rendered automatically by printing or computer graphics technology, or developed by a combination of methods, especially in a pseudo-photograph. A volatile image is the type of image that exists only for a short period of time. This may be a reflection of an object by a mirror, a projection of a camera obscura, or a scene displayed on a cathode ray tube. A fixed image, also called a hard copy image, is one that has been recorded on a material object, such as paper or textile by photography or any other digital process.

There are two types of images, still image and moving image. A still image is a single static image. A moving image is typically a movie (film) or video, including digital video. It could also be an animated display, such as a zoetrope.

Image display is used for displaying digital image data into a visual color image as a tool for real time 'Man-Machine Interface'. An image display system

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consists of a frame buffer, look up table, D/A converter (Digital/Analog converter) and a display device.

Frame buffer is an image memory that helps in reading of high speed digital image data. The size of the image memory is generally 512 ´ 512 to 2048 ´ 2048 picture elements. Look up table is a pre-set function that enables conversion from an input signal to an output signal in real time. Linear function, contrast enhancement function, gamma function, log function, etc., are the most frequently used pre-set functions. The D/A converter converts the digital image data in a frame buffer to an analog video signal.

Display Processor

Display processor is interpreter or part of specific hardware that converts display processor code into the form of images or pictures. The four main parts of the display system include, display file memory, display processor, display generator and display console. Figure 2.20 illustrates the block diagram of display system.

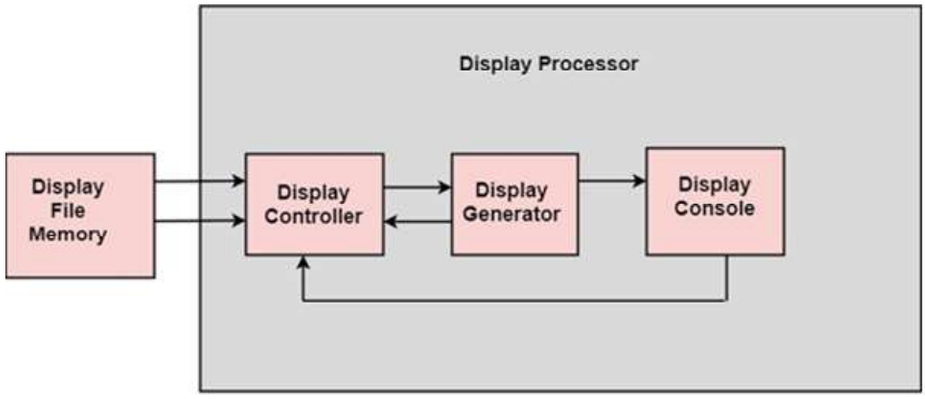

Fig. 2.20 *Block Diagram of Display System*

Display File Memory: Display file memory is typically used for generation of the image or picture. Basically, it is used for identification of graphic entities.

Display Controller: Display controller handles interrupt, maintains timings and is typically used for interpretation of instruction(s).

Display Generator: Display generator is used for the generation of character(s). It is also used to generate the curves.

Display Console: Display console contains CRT, Light Pen, Keyboard and the deflection system.

The raster scan system is a combination of the processing units. It consists of the Control Processing Unit (CPU) and a specific precise processor called a display controller. Display controller controls the operation and functioning of the display device. It is also termed as a video controller. The video controller in the output circuitry typically generates the horizontal and vertical drive signals, therefore,

the monitor can sweep. Following Figure 2.21 illustrates the architecture of a raster display system along with a display processor.

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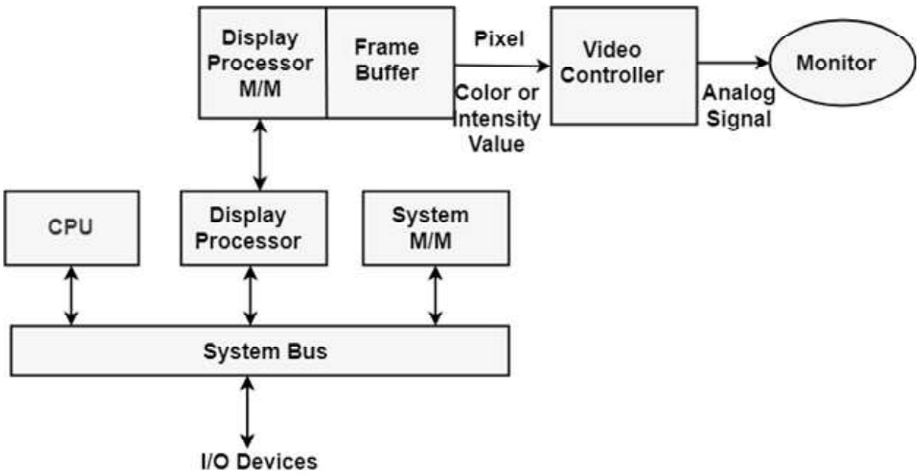


Fig. 2.21 *Architecture of a Raster Display System along with a Display Processor*

2.3.1 Basic Types and Image Files

Images can be generated and stored in the PC in typically two different ways. One is called ***vector art*** and the other is referred to as ***bitmapped***.

A piece of *vector art* is a file that contains descriptions of how to generate the image but not the actual image itself. A vector art program (generically called, drawing program) creates a sequential list of graphic commands to draw lines, curves, text, etc., with associated parameters such as screen location, size, color, rotation angle, width, style etc. This type of list-file is often referred to as a ***display list*** */file*. Such a file must be rasterized before it can be presented as an actual image on screen.

When you edit a vector graphic, you modify the properties of the lines and curves that describe its shape. You can move, resize, reshape, and change the color of a vector graphic without changing the quality of its appearance. Vector graphics are resolution-independent, meaning they can be displayed on output devices of varying resolutions without losing any quality.

Mostly, the CAD packages, business packages for drawing charts & graphs and some DTP package like COREL DRAW uses vector files of specific formats. Some of the vector file formats commonly used in the IT industries are

1. Postscript file
2. Computer Graphics Metafile (*.*CGM*)
3. Windows Metafile (*.*WMF*)
4. HPGL or, Hewlett Packard Graphics Language (*.*PLO*)
5. Data Exchange Format (*.*DXF*)

NOTES

Postscript files, developed by Adobe are generated by DTP packages and authoring systems while the WMF was developed by Microsoft and is an excellent format for image interchange between Windows applications. HPGL is an interpreted vector description language meant for the plotters and DXF is the most widely accepted format for interchange of engineering graphics data between different CAD packages like AutoCAD.

Another kind of vector image specifies the content in full, three-dimensional form. Here the objects are not what gets drawn in the image. Instead, a view of those objects is drawn. This substantially more complex process is called 3D-rendering.

A ***bitmapped image***, in contrast, has in the file the actual pixel image data. That is, it simply holds the color number for each dot or pixel in an image. The size of such files depends on the image size and how many colors are to be used per pixel, i.e., the color depth. For a 256-color range and standard VGA (640 × 480 pixels) full screen display, the size of a bitmap file is 640 × 480 × 8 bits i.e., 307200 × 8 bits or, 307200 bytes or, 300 KB. This is because, for each pixel 8 bits are required for storing color value anything upto 256.However true-color images (24 bit, more than 16 million color) provide the highest quality and they are the best way to represent photographs on computer screen. Out of the 24 bits per pixel in high quality true-color images, 8 bits are used to describe intensities of each of the three basic color signals – red, green and blue of *RGB color model*. White color is displayed when all RGB signals are at full intensity, and black occurs when there is no signal.

When you edit a bitmap graphic, you modify pixels, rather than lines and curves. Bitmap graphics are resolution-dependent because the data describing the image is fixed to a grid of a particular size. Editing a bitmap graphic can change the quality of its appearance. In particular, re-sizing a bitmap graphic can make the edges of the image ragged as pixels are redistributed within the grid. Displaying a bitmap graphic on an output device that has a lower-resolution than the image itself also degrades the quality of its appearance.

(a) The vector-image of a leaf is described by points through which lines & curves pass, creating the shape of the leaf's outline. The color of the leaf is determined by the color of the outline and the area enclosed by the outline.

(b) The bitmapped-image of a leaf is described by the specific location and color value of each pixel, creating a more realistic image.

Fig. 2.22 *Vector-Image and Bitmapped Image*

NOTES

Utilities like Windows Paintbrush or Paint Shop Pro generates *bitmapped* image files in *BMP* format or, in the more efficient *PCX* format.

Static bitmapped images are often compressed to reduce the file sizes and thus to save some disk space and shorten the time it takes to transfer those files over a communication link. The most common compressed file formats are

1. Graphics Image Format (*.*GIF*)
2. TIFF or Tagged Information File Format (*.*TIF*)
3. JPEG or Joint Photographic Experts Group (*.*JPG*)
4. Windows Bitmap (*.*BMP*)
5. Windows Device Independent Bitmap (*.*DIB*)

GIF, TIF, DIB and *PCX* files are compressed in ***lossless*** fashion using either *RLE*[6] or *LZW*[7] compression algorithm. That is, only truly redundant bits are squeezed out and they all can be returned exactly as they were when the file is decompressed. None of the original images data is deleted in the compression process.

JPEG, on the other hand, is an example of a ***lossy* compression** – data from the original image which is deemed to be redundant is thrown away in the compression process. (And as you would expect lossy compression yields smaller compressed files than does lossless compression.) This means that the image resulting from the decompressed files will differ from the originals to some degree. The tricky part of these algorithms is their attempt to lose only "unimportant" features of the images and people are least likely to notice those absent features while viewing the reconstructed image.

So far as motion picture in MPCs is concerned, JPEG compression still might not be sufficient to let you achieve full-screen, full-motion video. The latest in this field is the universally accepted *MPEG* (*Motion Pictures Expert Group*) standard. The technique basically used by the *MPEG* compression algorithms is to record only the changes from one frame of video to the next. This technique greatly reduces the file size and computational overhead as most of the time a frame of video is very much like the frame preceded it.

Researches are on for evolving more effective compression techniques. The objective is to reduce the compression as well as decompression cost & time without any significant degradation in image quality but at the same time enhancing the storage savings.

JPEG files being the most widely used compressed image file standard we discuss the JPEG compression scheme separately with greater detail.

2.3.2 JPEG Compression Scheme

In multimedia different signals we measure for digitization are either time varying (audio) or space varying (still image) or vary with both time and space (video).

NOTES

The number of times a time-varying periodic signal (such as audio, radio or light) changes during a unit of time is the frequency of the signal. Similarly for a space-varying signal such as the color intensities of pixels in an image, frequency or more specifically ***spatial frequency*** is the number of times the intensities varies over a unit of distance. The component frequencies (for different colors) and amplitudes (color values) for each frequency can be computed for an image using *Fourier Transform* and can be displayed graphically in the ***frequency domain***. The horizontal axis represents frequency and the vertical axis represents amplitude in such frequency spectrum graph — the spikes at different frequencies correspond to different signal components.

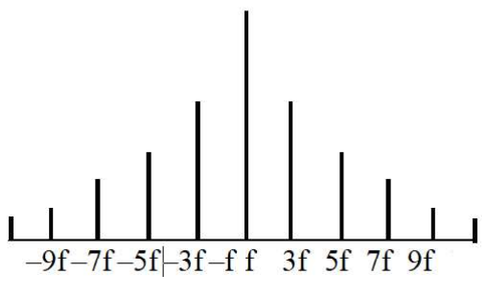


Fig. 2.23 *Frequency spectrum*

The spike at zero frequency is called the DC component, which we can think as the average value of the signal. The other (non-zero) spikes are called AC components. The high frequency components are associated with abrupt and frequent change in pixel intensity across the image. Psychophysical experiments suggest that people do not perceive the effect of high frequencies (wide variation of color within small area) very accurately. So they are less likely to notice any change if some of very high special frequency components are removed from an image-signal. JPEG's approach is basically to remove special redundancy that is to reduce high-frequency contents of an image and then efficiently code the result into a bitstring.

The JPEG encoder works following the steps listed below:

Step 1: Transform RGB to YIQ or YUV and subsample color.

Step 2: Perform DCT on image blocks.

Step 3: Apply quantization

Step 4: Perform zigzag ordering and run-length encoding

Step 5: Perform entropy coding

NOTES

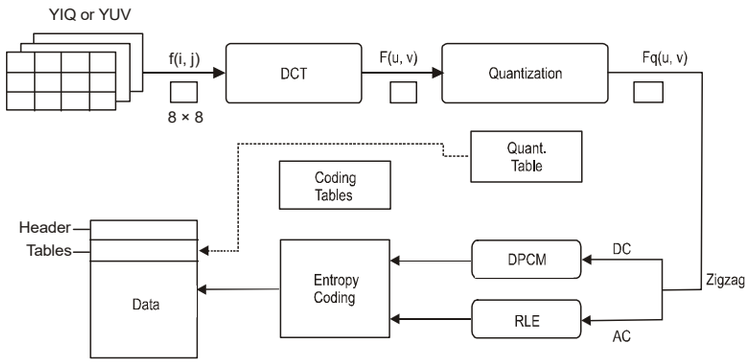
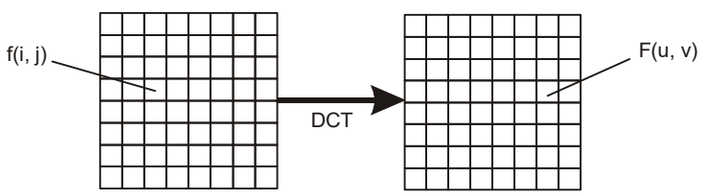


Fig. 2.24 *Block diagram for JPEG encoder*

Step 1: JPEG works for both color and gray scale images. In case of color images in **YIQ** or **YUV** format, the JPEG encoder works on each component separately using the same routines. If the source image is in a different color format say RGB, the encoder performs a color space conversion to yield YIQ or YUV image signal. When the JPEG image is needed for viewing, the three compressed image components can be decoded independently and eventually combined.

Step 2: An image is a function say $f(i,j)$ of the two dimensions x and y. JPEG uses 2D ***Discrete Cosine Transform*** **or DCT** (similar to Discrete Fourier Transform or DFT) to transform the image into its frequency components. In computational terms DCT takes an array of pixel values $f(i,j)$ and produces a same sized two dimensional array of coefficients $F(u,v)$, representing the amplitude of the special frequency components in two directions.



For a N x N block of $f(i,j)$ values, the $N \times N$ $F(u,v)$ values are given by,

$$F(u,v) = \frac{1}{\sqrt{(2N)}} C_u C_v \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} f(i, j) \cos \frac{[(2i+1)u\pi]}{2N} \cos \frac{[(2j+1)v\pi]}{2N} \quad (1)$$

$$C_u, C_v = \begin{cases} 1/\sqrt{2} \text{ for } u, v = 0 \\ 1 \text{ otherwise} \end{cases}$$

It shows that DCT computation takes the form of a nested double loop, iterating over the two dimensions of the array. The computational time for each DCT coefficient is proportional to the image size in pixels ($i \times j$) and the entire DCT computation time is proportional to the square of the size. To reduce the computational time instead of operating on the entire image the image is divided

NOTES

into 8 × 8 pixel blocks ($N = 8$) and the DCT is applied to each block separately. The output for each block is 64 numbers DCT coefficients.

DCT transform itself does not actually compress an image but provides scope for compression as it explicitly separates the lower and higher frequency components. Since useful image content vary relatively slowly from point to point across an image they fall into the lower frequency group. As the frequency gets higher in few areas of the image containing less useful details and noises, it becomes less important to represent the corresponding DCT coefficients accurately. It may even be set to zero or near zero without losing much perceptible image information.

While the JPEG encoder uses the Forward DCT or FDCT technique, the JPEG decoder uses the Inverse DCT or IDCT technique to reproduce an image from its compressed form. The IDCT takes 64 DCT coefficients (which at that point have been dequantized) and reconstructs a 64-point output image signal or 8 × 8 block of pixels. IDCT uses the following generalized iterative calculation for $N \times N$ DCT coefficients.

$$f(i,j) = \frac{1}{\sqrt{(2N)}} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C_u C_v F(u,v) \cos \frac{[(2i+1)u\pi]}{2N} \cos \frac{[(2j+1)v\pi]}{2N} \quad (2)$$

$$Cu,\ Cv = \begin{cases} 1/\sqrt{2} \text{ for } u, v = 0 \\ 1 \text{ otherwise} \end{cases}$$

Step 3: With the aim of reducing the total number of bits needed for a compressed image, DCT coefficients for different frequencies are quantized to different number of levels with fewer levels being used for high frequencies. JPEG uses a 64-element ***Quantization Table***, which must be specified by the application (or user) as an input to the encoder. The Table uses 8 bits per entry and each element $Q(u,v)$ can be any integer value from 1 to 255, which specifies the step size of the quantizer for its corresponding DCT coefficient. The quantized DCT coefficients $F_q(u,v)$ are mathematically represented by,

$$F_q(u,v) = \text{round } \frac{[F(u,v)]}{Q(u,v)} \quad (3)$$

The quantization process reduces the space needed to store an image in two ways. First, after quantization many components will end up with zero coefficients. Second, fewer bits are required to store the non-zero components as their value reduces upon division. The degree of compression achieved can be changed by customizing or simply scaling the quantization matrix.

Quantization is a many-to-one mapping, and therefore is fundamentally lossy. It is the principal source of lossiness in DCT-based encoders.

The inverse of the quantization step is ***dequantization*** used prior to IDCT by the decoder and the dequantized DCT coefficients $F_q'(u,v)$ are mathematically represented by,

$$F_q'(u,v) = F_q(u,v)\ Q(u,v) \quad (4)$$

NOTES

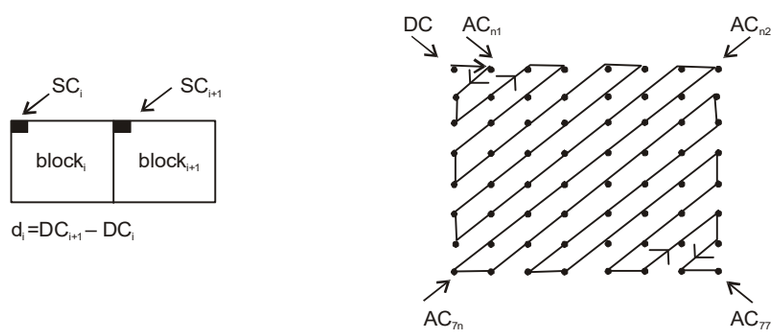
Step 4: Before entropy coding of compressed data two additional lossless compression steps are carried out on the quantized DCT coefficients. These are run-length encoding **RLE** on AC coefficients and differential pulse code modulation (DPCM) on DC coefficients.

Step 4a: The quantized DCT coefficients corresponding to low frequency perceptible image information is concentrated at the top left corner of the $F_q(u,v)$ matrix. As we move away from the top left corner of the matrix in both directions, the frequencies increase. And the likelihood is that the bottom right part of most matrix will have high frequency components which are zeroed out by quantization. In order to create a bitstream where non-zero (or typically higher value) coefficients are placed before zero-value (or typically small value) coefficients, the zigzag sequence shown in the following figure is used to read the coefficients into the bitstream. Such **zigzag scanning** produces in all probability long runs of zeros (specially at the end of the matrix), which can be concatenated using RLE.

RLE actually replaces values by a pair [**RUNLENGTH**, VALUE] for each run of zero-value AC coefficients, where RUNLENGTH is the number of zeroes in the run and VALUE is the next non-zero AC coefficient.

Step 4b: Each 8 × 8 image block has only one DC coefficient. Though the DC coefficients are usually large values the differences between them are relatively smaller as DC coefficient is unlikely to change within a short distance. This makes DPCM, i.e. recording only the differences of values of successive DC coefficients, an ideal scheme for coding DC coefficients.

If DC_i denotes the *DC* coefficient of the *i*-th block then the difference $d_i = DC_{i+1} - DC_i$ are the quantities that are coded for $i = N$ numbers of image blocks. Also $d_0 = DC_0$. It should be noted that unlike the RLE of *AC* coefficients, which is performed on each individual block, DPCM for *DC* coefficients in JPEG is carried out on the entire image at once.



(a) DPCM difference *(b) Zigzag sequence*

Fig. 2.25

Step 5: The DC and AC coefficients finally undergo an entropy coding step. Only the basic (or baseline) **entropy coding** method which uses **Huffmann coding** and supports 8-bit pixels in the image are discussed below.

NOTES

Step 5a: Each DPCM coded DC coefficient is represented by a pair [SIZE, AMPLITUDE] where SIZE indicates how many bits are needed for representing the coefficients and AMPLITUDE contains the actual bits. For example codes 150, 3, –3 will be represented by (8, 10010110), (2, 11), (2, 00) respectively. Now SIZE is Huffman coded. SIZE 2 might be represented as a single bit (0 or 1) if it appeared most frequently. Huffman coding scheme uses 1 bit for the most frequently occurring SIZE, 2 bits for the next most frequent SIZE and so on saving in space for storing DPCM coded DC coefficient data. Huffman codes are thus variable-length codes (VLC) and the coding requires that one or more sets of Huffman code tables be specified by the application which uses JPEG. The same tables used to compress an image are also needed to decompress it.

Step 5b: The AC coefficients, which are **RLE** coded as (**RUNLENGTH**, VALUE) are further coded when VALUE is represented by (SIZE, AMPLITUDE). In JPEG implementation,

Symbol 1: (RUNLENGTH, SIZE)

Symbol 2: (AMPLITUDE)

Here symbol 1 is Huffman coded, symbol 2 is not. Symbol-2 is encoded with a "variable-length integer" (**VLI**) code whose length in bits is specified in a separate table.

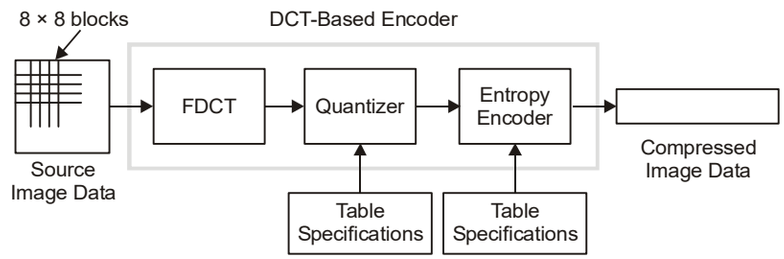


Fig. 2.26(a) *DCT-based encoder processing steps*

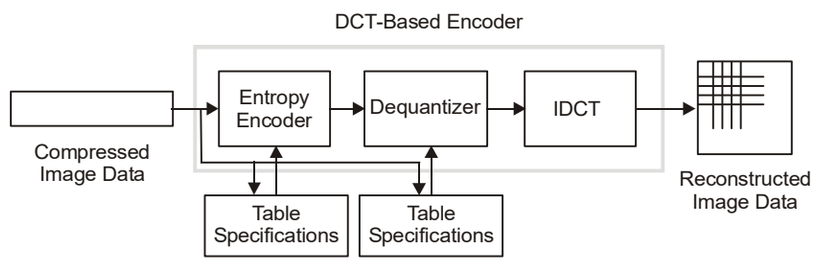


Fig. 2.26(b) *DCT-based decoder processing steps*

An example of baseline compression and encoding of a 8 × 8 block of 8-bit samples of an image (Fig. 2.27(a)) is discussed below. The small variations from sample to sample indicate the predominance of low spatial frequencies.

NOTES

After subtracting 128 from each sample for the required level-shift from unsigned integer range $[0, 2^8 - 1]$ to signed integer range $[-2^7, 2^7 - 1]$ the 8×8 block is input to the FDCT following equation (1). Figure 2.27(b) shows (to one decimal place) the resulting DCT coefficients.

Figure 2.27(c) is the example quantization table for luminance (grayscale) components included in the informational annex of the draft JPEG standard part 1. Figure 2.27(d) shows the quantized DCT coefficients, normalized by their quantization table entries, as specified by equation (3). At the decoder these numbers are dequantized or denormalized according to equation (4), and input to the IDCT following equation (2).Finally, figure 2.27(f) shows the reconstructed sample values, remarkably similar to the originals in (a).Of course, the numbers in figure 2.27(d) must be Huffman-encoded before transmission to the decoder.

The first number of the block to be encoded is the DC term, which must be differentially encoded. If the quantized DC term of the previous block is, for example, 12, then the difference is +3. Thus, the intermediate representation is (2)(3), for SIZE = 2 and AMPLITUDE = 3.

139	144	149	153	155	155	155	155
144	151	153	156	159	156	156	156
150	155	160	163	158	156	156	156
159	161	162	160	160	159	159	159
159	160	161	162	162	155	155	155
161	161	161	161	160	157	157	157
162	162	161	163	162	157	157	157
162	162	161	161	163	158	158	158

(a) source irnage samples

235.6	−1.0	−12.1	−5.2	2.1	−1.7	−2.7	1.3
−22.6	−17.5	−6.2	−3.2	−2.9	−0.1	0.4	−1.2
−10.9	−9.3	−1.6	1.5	0.2	−0.9	−0.6	−0.1
−7.1	−1.9	−0.2	1.5	0.9	−0.1	0.0	0.3
−6.6	−0.8	1.5	1.6	−0.1	−0.7	0.6	1.3
1.8	−0.2	1.6	−0.3	−0.8	1.5	1.0	−1.0
−1.3	−0.4	−0.3	−1.5	−0.5	1.7	1.1	−0.8
−2.6	1.6	−3.8	−1.8	1.9	1.2	−0.6	−0.4

(b) forward DCT coefficients

16	11	10	16	24	40	51	61
12	12	14	19	26	58	60	55
14	13	16	24	40	57	69	56
14	17	22	29	51	87	80	62
18	22	37	56	68	109	103	77
24	35	55	64	81	104	113	92
49	64	78	87	103	121	120	101
72	92	95	98	112	100	103	99

(c) quantization table

15	0	−1	0	0	0	0	0
−2	−1	0	0	0	0	0	0
−1	−1	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

(d) normalized quantized coefficients

240	0	−10	0	0	0	0	0
−24	−12	0	0	0	0	0	0
−14	−13	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

(e) denormalized quantized coefficients

144	146	149	152	154	156	156	156
148	150	152	154	156	156	156	156
155	156	157	158	158	157	156	155
160	161	161	162	161	159	157	155
163	163	164	163	162	160	158	156
163	164	164	164	162	160	158	157
160	161	162	162	162	161	159	158
158	159	161	161	162	161	159	158

(f) reconstructed image sample

Fig. 2.27

Next, the quantized AC coefficients are encoded. Following the zigzag order, the first non-zero coefficient is –2, preceded by a zero-run of 1. This yields an intermediate representation of (1,2)(–2). Next encountered in the zig-zag order are three consecutive non-zeros of amplitude –1. This means each is preceded by a zero-run of length zero, for intermediate symbols (0,1)(–1). The last non-zero coefficient is –1 preceded by two zeros, for (2,1)(–1). Because this is the last non-zero coefficient, the final symbol representing this 8 x 8 block is EOB, or (0,0).Thus, the intermediate sequence of symbols for this example 8x8 block is:

(2)(3), (1,2)(–2), (0,1)(–1), (0,1)(–1), (0,1)(–1), (2,1)(–1), (0,0)

NOTES

Next the codes themselves must be assigned. For this example, the VLCs (Huffman codes) from the informational annex will be used. The differential-DC VLC for this example is:

(2) 011

The AC luminance VLCs for this example are:

(0,0) 1010

(0,1) 00

(1,2) 11011

(2,1) 11100

The VLIs specified in the informational annex are related to the two's complement representation. They are:

(3) 11

(–2) 01

(–1) 0

Thus, the bit-stream for this 8x8 example block is as follows.

01111110110100000000001110001010

Note that 31 bits are required to represent 64 coefficients, which achieves compression of just under 0.5 bits/sample.

The following figure 2.28 provides a hierarchical view of the organization of the bitstream for JPEG images. Here, a frame is a picture, a scan is a pass through the pixels (e.g., the red component), a segment is a group of blocks, and a block consists of 8 x 8 pixels.

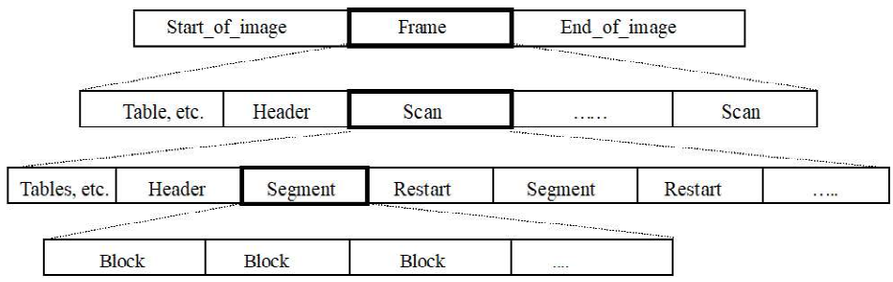


Fig. 2.28 *JPEG bitstream*

Example of some header information are:

- **Frame header**
  - Bits per pixel
  - (Width, height) of image
  - Number of components
  - Unique ID (for each component)

– Horizontal /vertical sampling factor (for each component)

– Quantization table to use (for each component)

- Scan header

  – Number of components in scan

  – Component ID (for each component)

  – Huffman / Arithmetic coding table (for each component)

NOTES

JPEG Modes

The JPEG standard supports numerous modes (variation). Some of the commonly used ones are:

- **Sequential Mode**
- **Progressive Mode**
- **Hierarchical Mode**
- **Lossless Mode**

Sequential Mode: This is the default JPEG mode we have discussed so far. Each gray level image or color image component is encoded in a single left-to-right, top-to-bottom scan. The "Motion JPEG" video codec uses Baseline Sequential JPEG, applied to each image frame in the video.

Progressive Mode: The key difference with the sequential mode is that each image component is encoded in multiple scans rather than in a single scan. The first scan(s) encode a rough but recognizable version of the image (with few bits) which can be transmitted quickly in comparison to the total transmission time , and are refined by sending more data bits in succeeding scans until reaching a level of picture quality that was established by the quantization tables. JPEG progressive mode is widely supported in web browsers and is most useful when the speed of the communication line is low. While viewing images online in web user has a choice whether to continue receiving image data after the first scan(s).

After each block of DCT coefficients is quantized, it is stored in an additional buffer memory before the input to entropy encoder. The buffered coefficients are then partially encoded in each of multiple scans.

Progressive JPEG can be realized in one of the following two ways. The main steps (DCT, quantization, etc.) are identical to those in sequential mode.

Spectral selection: This scheme takes advantage of the spectral (spatial frequency spectrum) characteristics of the DCT coefficients: the higher AC components provide only detail information. In the first run, the quantised DCT coefficients of low frequencies are passed to entropy coding. In successive runs coefficient of higher frequencies are processed.

Successive approximation: Instead of gradually encoding spectral bands, all DCT coefficients are encoded simultaneously, but not encoded to their full

NOTES

(quantized) accuracy in a given scan. The Most Significant Bits (MSBs) of the coefficients are encoded first while less significant bits are encoded in subsequent scans.

Hierarchical mode: This mode provides a "pyramidal" or hierarchical encoding of an image at multiple resolutions, each differing in resolution from its adjacent encoding by a factor of two in either the horizontal or vertical dimension or both. The encoded image at the lowest resolution is basically a compressed low-pass-filtered image, whereas the image at successively higher resolutions provide additional details (differences from the lower–resolution images). Similar to Progressive JPEG, Hierarchical JPEG images can be transmitted in multiple passes with progressively improving quality.

Lossless mode: Lossless JPEG is a very a special case of JPEG which indeed has no loss in its image quality. It does not use DCT-based method. Instead it employs a simple differential (predictive) coding method. Following figure 2.29 shows the main processing steps for a single-component image.

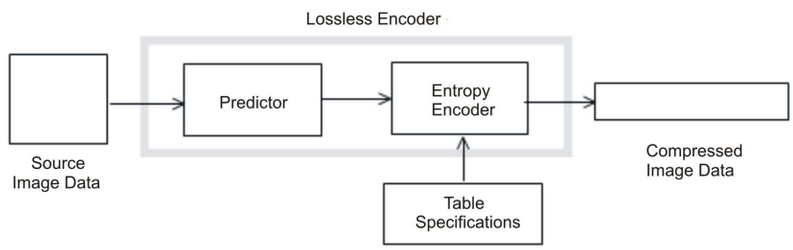
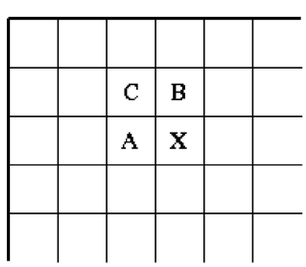


Fig. 2.29

A *predictor* combines the values of up to three neighboring samples (A, B, and C) to form a prediction of the sample indicated by X in Figure 2.30. This prediction is then subtracted from the actual value of sample X, and the difference (prediction residual) is encoded. losslessly by either of the entropy coding methods - Huffman or arithmetic. Any one of the eight predictors listed in following table (under "selection-value") can be used.

Table 2.1



Selection-value	Prediction
0	no prediction
1	A
2	B
3	C
4	A + B – C
5	A + ((B – C)/2)
6	B + ((A – C)/2)
7	(A + B)/2

Fig. 2.30

NOTES

Selections 1, 2, and 3 are one-dimensional predictors and selections 4, 5, 6 and 7 are two-dimensional predictors. Selection-value 0 can only be used for differential coding in the hierarchical mode of operation.

This lossless mode is rarely used, since its compression ratio is very low compared to other lossy modes. However, the newly developed JPEG-LS standard is specifically aimed at lossless image compression.

2.3.3 Image Processing

Developers can create bitmaps by scanning photographs with a color scanner or by digitizing video frames using a video camera and frame grabbing equipment. Once the images are converted into any *bitmapped* format, pixel-by-pixel processing operations can then be carried out on the image using standard image processing tools. These operations sharpen the images and also create interesting effects.

Histograms: A histogram graphs the number of pixels at each brightness level in an image. The X axis of the histogram represents the color values from darkest at the far left to brightest at the far right; the Y-axis represents the total number of pixels with a given value. If part of the image is selected, the histogram represents only the selected pixels.

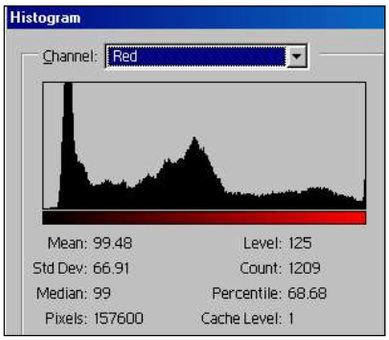


Fig. 2.31 *This is the Histogram of an image of multicolored flowers in Adobe Photoshop. Values at the bottom indicate the red color intensity level at a particular point on the graph (pointed by the mouse) and no. of pixels in the image with that intensity level. Similar graphs are displayed for Green, Blue and Luminosity levels of this image.*

A histogram can be scrutinized to ascertain,

1. If the image portion is too dark or too light,
2. If there is too little contrast or too much,
3. If there is a color cast that should be removed, etc.

An image that is too flat, too high in contrast, too bright or too dark may need tonal correction. **Histogram sliding** (which actually adds to or subtracts from all pixels a constant value) is used to change the overall visible effect of brightening or darkening the image[8].

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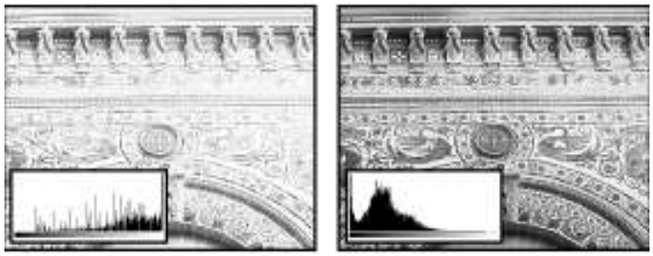

Fig. 2.32 The histogram shows how the pixels' values are distributed in an image; whether there is clustering of pixels in the shadows (i.e. in the left part of the histogram), in the midtones (in the middle), or in the highlights (in the right). A low contrast image appears dull with no highlights or shadow. Most of the pixels in the histogram appear clustered in the centre and a few at the ends. A high contrast image has very dark and light areas with a few middle tones. In the figure the left image is original with details concentrated in the highlights. Using Image Processing tools more contrast is added to produce the tone-corrected picture in the right.

Filters: Filters are great tools for modifying image qualities by blurring or sharpening, changing focus or colors, creating bumps or extrusions; it can be used to obliterate image data and replace it with new image and apply special effects etc.

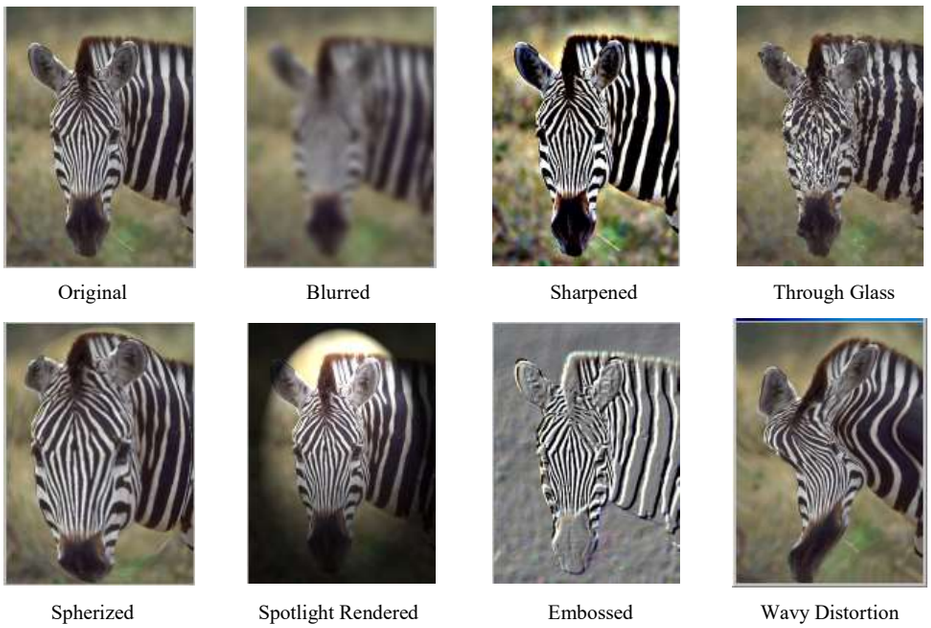

Fig. 2.33 *Various effects induced by filters*

The ***Blur Filters*** work by lessening the difference of intensities between adjacent pixels, creating softening or blurring of the image. In contrast, the ***Sharpen Filters*** lighten the lighter pixels and darken the darker pixels and bring the fuzzy edges of objects into better focus to make the image appear more distinct. Unfortunately though, sharpening exaggerates any blemishes in the original. However

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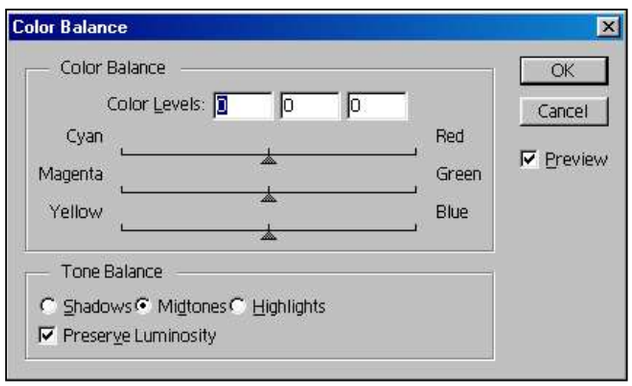
using ***Noise Filters*** you can eliminate those blemishes by blending them into the surrounding areas. You can simulate the way an object looks when viewed through a glass of water or a pane of glass or when under rippling water. You can also warp, twist, wrench and bend images into new shapes. All these are done using ***Distort Filters***, which work by actually moving pixels around in your image. To simulate the effect of light shining on an image or sun bouncing off the lens, use ***Render Filters***.

Color Control: There are standard tools that let you change the mixture of colors in a color image. The Hue, Saturation and Brightness of individual **color channels** (of **RGB** or **CMYK**) can be controlled over a selected portion or the entire image. You can also choose Shadows, Midtones, or Highlights to select the tonal range on which you want to focus the changes. The mode of image color can well be changed as often as required. A full color image can be converted to a gray scale image and conversely a gray scale image can be colorised with precise controls.

Blue morning sky (Original photo)

The blue sky is converted to evening sky

Fig. 2.34



The above editing is done in Adobe Photoshop using this Color Balance tool. The Red & Yellow Color level is increased in the Shadows and Midtones. As the colors are changed the corresponding effect on the image can be previewed simultaneously. After the color editing the overall brightness of the image is enhanced.

Fig. 2.35 *Color balance*

On specifying a ***Threshold*** pixel value grayscale or color images can be converted to high-contrast, black-and-white images. All pixels lighter than the threshold are converted to white and all pixels darker to black.

NOTES

Object Editing: One of the most interesting features of image processing is the flexibility with which the content of an image can be modified. In almost all the image editing packages, you will find some common tools for *painting*, *selecting, cut-copy-paste operation, erasing,* ***zooming*** and *drawing*. With these tools you can select a portion of an image, can copy it to the clipboard and then paste it at the desired location (ref. Fig. 2.35). Thus you can easily copy-paste the image of a flower to the image of a plant and can add multiple copies of the flower to its branches. Similar methods can be adopted to completely fill (the image of) a stadium-gallery which is actually partially filled with spectators. It is possible to *move* and *reorient* objects in a frame. Thus a rose-stick lying on the table can be digitally placed into a vase. You can simply erase unwanted portions of an image and can correct the erased portion with the surrounding pixel color using the *pick-color* tool. Using the *draw-pencil* or *paint-brush* of appropriate width you can even draw a piece of white cloud in the background of the photo-scanned image of a clear blue sky. And then make it more realistic with precise color and brightness control. With professional use of digital image manipulation techniques interesting effects are now created in the movie scenes.

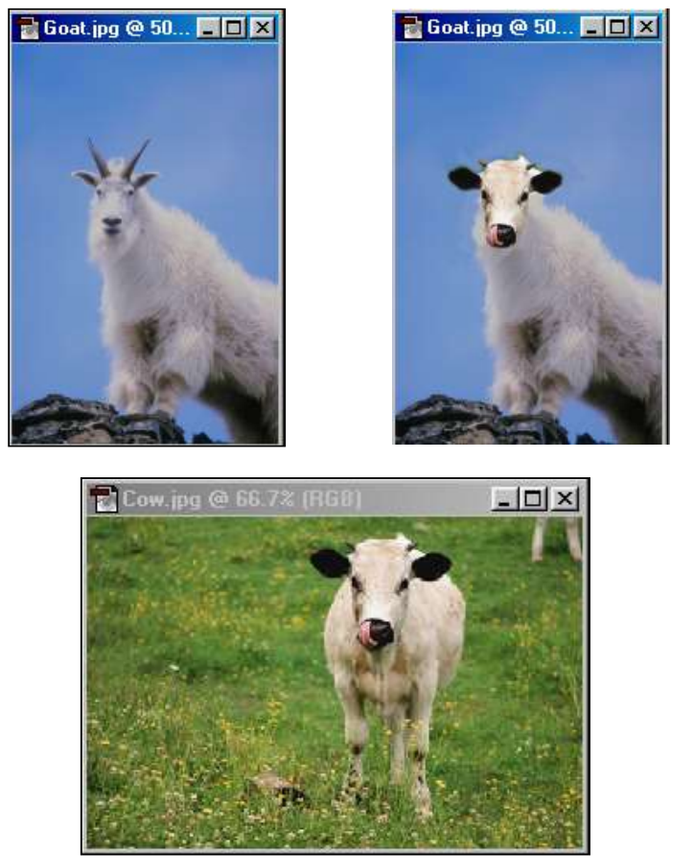


Fig. 2.36 *The image of this goat is manipulated. The face of the cow from Cow.jpg is copied and then pasted on the face of the goat in the original Goat.jpg. Then with some careful trimming and color correction the modified Goat.jpg has become realistic. How do you like it? — a strange looking cow !*

NOTES

How Image Processing is Done

Image processing is actually performed by computing a new value for each pixel in an image. One simple way is to compute a pixels value ($p¢$) solely on the basis of its old value (p), without regard to any other pixel. Mathematically it can be represented by a transformation or mapping function $f(\ )$, such that,

$$p' = f(p)$$

One example of $f(p)$ is $W - p$, where W represents white color value; $f(p)$ being applied on an image produces an inverted (negative) image. Such individual pixel-based processing of image is known as ***pixel point processing***. By suitably choosing the mapping function, color correction and alteration, brightness and contrast adjustments can be done on an image. Brightness adjusts the value of each pixel up or down uniformly – increasing brightness makes every pixel lighter while decreasing brightness makes every pixel darker. On the other hand enhancing contrast makes the lighter pixels even lighter while at the same time making the darker pixels even darker.

In terms of brightness (B) and contrast (C), p' and p are related linearly as, $p' = f(p) = C\,p + B$, which is analogous to $y = m\,x + c$; C is the gradient and B is the y-axis intercept of the p'-p line, p being plotted along x-axis and $p' = f(p)$ along y axis.

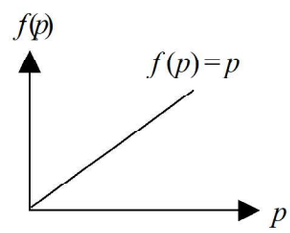


Fig. 2.37

Another class of image processing, known as ***pixel group processing***, works by computing each pixel's new value as a function of not just it's old value, but also of the values of the neighbouring pixels. ***Convolution*** is one such operation, which combines a pixel's value with those of its neighbours by multiplying together two arrays of numbers, generally of different sizes, but of the same dimensionality. One of the input arrays is normally just a gray level image. The second array is a two-dimensional array of weights and is known as the ***convolution mask***. The convolution is performed by sliding the mask over the image, generally starting at the top left corner, so as to move the mask through all the positions where it fits entirely within the boundaries of the image. Each mask position corresponds to an array (same size as the mask) of pixel values known as ***convolution kernel*** and the resultant convolution output is a single pixel.

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If a pixel has coordinates (x, y), so that it has neighbours at $(x-y, y+1)$, $(x, y+1)$,…. $(x+1, y-1)$ and we apply a convolution mask of the form:

$$\begin{pmatrix} a & b & c \\ d & e & f \\ g & h & i \end{pmatrix}$$

the value p' computed for the new pixel at (x, y) is,

$$p' = a\,p_{x-1,y+1} + b\,p_{x,y+1} + c\,p_{x+1,y+1} + d\,p_{x-1,y} + e\,p_{x,y} + f\,p_{x+1,y} + g\,p_{x-1,y-1} + h\,p_{x,y-1} + i\,p_{x+1,y-1}$$

where $p_{x,y}$ is the old value of the pixel at (x, y) and similarly the other 'p's.

If the image (I) has M rows and N columns, and the mask has m rows and n columns, then the size of the output image (O) will have $M-m+1$ rows, and $N-n+1$ columns.

Mathematically we can generalize 2D convolution as:

$$O(i, j) = \sum_{k=1}^{m} \sum_{l=1}^{n} I(i+k-1, j+l-1)\, K(k, l)$$

where i runs from 1 to $M-m+1$ and j runs from 1 to $N-n+1$.

The transformation carried out by convolution in effect remove or attenuate certain spatial frequency in an image and hence is termed as *filtering* operation.

A classical ***blur* filter** (or in other terms ***low pass* filter**) for example is:

$$\begin{pmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{pmatrix}$$

Such filter smoothes out the sharpness at the edges (characterized by abrupt transition from high pixel value to relatively smaller values) by reducing the difference of the adjacent pixel values. In fact blur filter also known as ***mean filter*** replaces each pixel value in an image with the mean ('average') value of its neighbours, including itself.

On the contrary a ***sharpen* filter** (or ***high pass* filter**) is:

$$\begin{pmatrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{pmatrix}$$

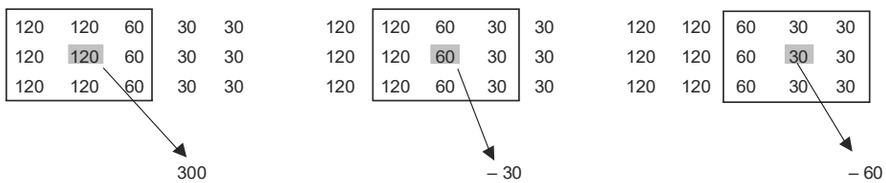
This mask filters out the low frequency components. By subtracting values of the adjacent pixels (by multiplying -1), while magnifying the central value (by multiplying 9), it eliminates any value that is common to the central pixel and its surroundings.

NOTES

If we apply the above mask or filter to a convolution kernel where there is a gradual discontinuity, such as

$$\begin{matrix} 120 & 60 & 30 \\ 120 & 60 & 30 \\ 120 & 60 & 30 \end{matrix}$$

assuming that all the pixels in the surrounding and to the left have the value 120 and those to the right 30, the new values computed on the central row will be 300, –30 and –60. The 3 x 3 masking is shown below.



Since negative pixel values are not allowed –30 and –60 pixels values will be set to 0. So, in effect the gradual transition 120 → 60 → 30 will be replaced by a hard (sharp) line, while regions of constant value on either side will be left unchanged.

It should be noted that these blur and sharpen filter have no effect over regions where the pixels all have the same value.

Another common type of filter called *unsharp mask* is used for producing an edge image. Following are some examples of 3 × 3 unsharp mask that produces scaling followed by addition/subtraction.

$$\begin{pmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{pmatrix} \begin{pmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{pmatrix} \begin{pmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{pmatrix}$$

Geometric Transformation

We have seen how geometric transformations like translation, scaling, reflection, rotation and shearing are carried out on graphic entities by simply transforming the definition points and then regenerating the entities. Applying geometric transformation to bitmapped images is somewhat different since we have to transform every pixel, and this will often require the image to be resampled. The scale operator performs a geometric transformation, which can be used to shrink or zoom the size of an image (or part of an image). Image reduction, commonly known as ***subsampling***, is performed in two ways. One is the replacement method where one pixel value within a local neighbourhood is chosen (perhaps randomly) to be representative of its surroundings. (This method is computationally simple, but can lead to poor results if the sampling neighbourhoods are too large.) The other method interpolates between pixel values within a neighbourhood by taking a statistical sample (such as the mean) of the local intensity values.

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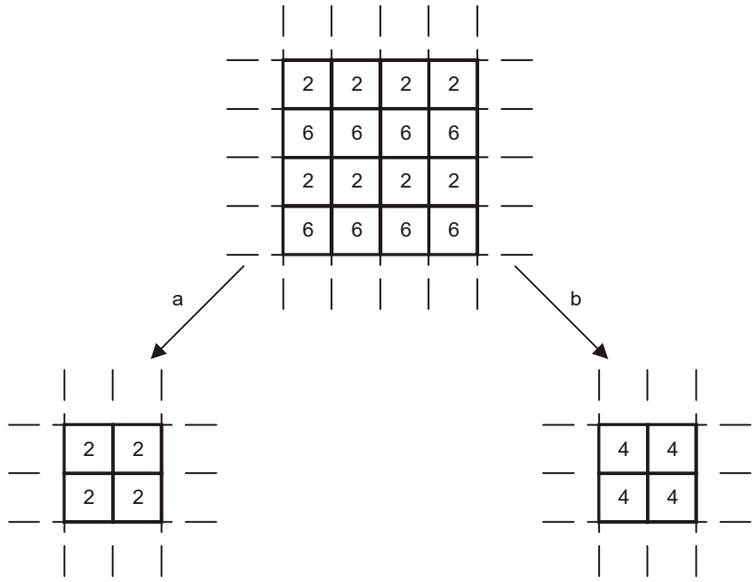

Fig. 2.38 *Methods of subsampling. a) Replacement with upper left pixel, b) Interpolation using the mean value.*

An image (or regions of an image) can be zoomed either through pixel replication or interpolation. Fig 2.38 shows how pixel replication simply replaces each original image pixel by a group of pixels with the same value (where the group size is determined by the scaling factor). Alternatively, interpolation of the values of neighbouring pixels in the original image can be performed in order to replace each pixel with an expanded group of pixels. Most implementations offer the option of increasing the actual dimensions of the original image, or retaining them and simply zooming a portion of the image within the old image boundaries.

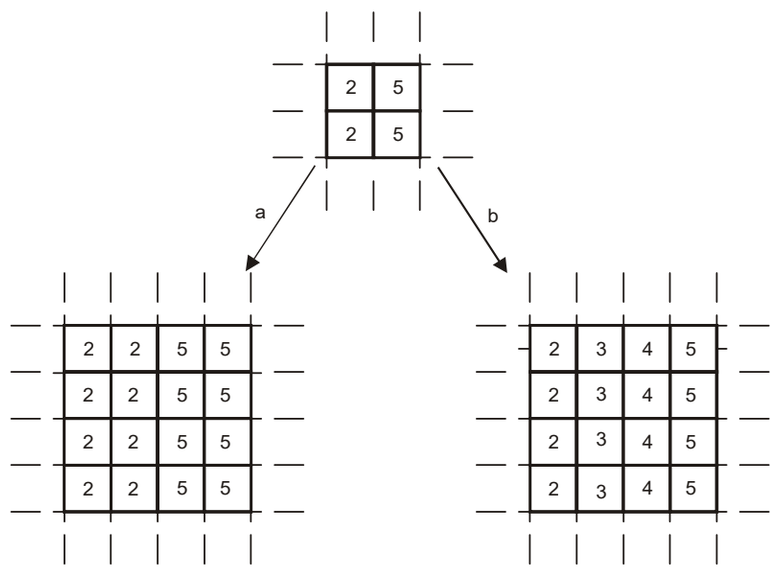

Fig. 2.39 *Methods of zooming. (a) Replication of a single pixel value, (b) Interpolation.*

2.3.4 3D Images and Operations

NOTES

3D images are much more complex than 2D images because greater amount of information is needed to create a realistic 3D world. In addition, several mathematical operations must be used in order to project this 3D world on a computer screen.

When you look at the world, your eyes and brain do this automatically. Most of the operations that allow you to perceive a three-dimensional world occur so seamlessly that you do not even realize they are happening. Your eyes and brain do this automatically. Have you ever wondered how you can look at a natural scenery: a mountain range, forest and a lake, for example and know that the mountains are farther away than the lake? This occurs through a complex interaction of visual effects – light levels, shadowing, relative motion – combined with your own perception of how the world works. The job of a 3D graphics engine is to duplicate this to whatever extent possible, so that what you see on the screen seems realistic to the eye.

3D images are handled inside the computer using abstract models. Usually, each 3D object is composed of hundreds or even thousands of small triangles (or other polygons) that describe its structure. When the program wants to move an object, it manipulates the corners of the triangles to create movement. (This is highly simplified of course but gives you the general idea). Of course real objects aren't made up of thousands of triangles but doing it this way is necessary in order to do the 3D effect.

The heavy computation is involved in converting these hollow triangles into solid surfaces. In real world, objects aren't islands; they interact. They overlap one another, cast shadows, reflect light, and appear dimmer when distant. There are very complex mathematical equations that are used to determine when an object is visible in a scene based on a given angle, what color it should be, etc. If you are playing a 3D game and want smooth animation, these calculations must be redone 20+ times per second! This is why 3D accelerators are used – they are customized to performing these resource-intensive computations.

Each time the screen is recalculated (due to movement in a game, for example), it is necessary to recalculate the color and intensity of each pixel on the 2D screen. This is done by applying different 3D computations to the scene – a process that is called Rendering. Here are some of the more common 3D operations:

Gouraud Shading This is an algorithm that is used to give 3D surfaces a realistic shading. The effect helps the object appear to have depth and helps to define the shape better. It is a popular computation that is used in many 3D games and Engineering design softwares.

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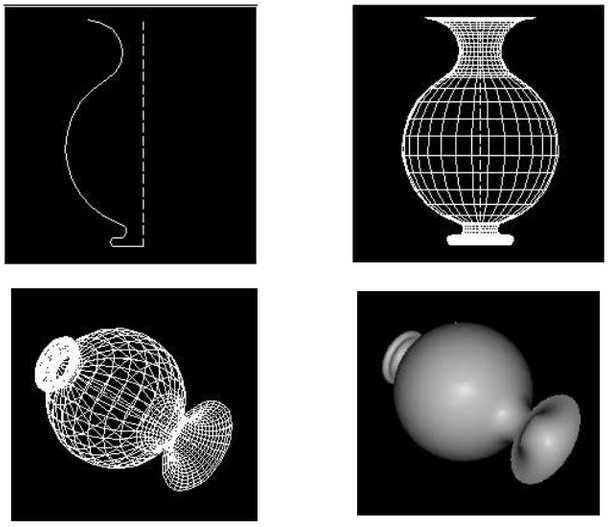

Fig. 2.40 *Rendering of the wireframe object (a surface by revolution) using gouraud shading in AutoCAD*

Clipping: This operation determines what part of an object is visible on the screen and "clips out" any part that the user cannot see. This saves rendering time since the parts of objects that are off-screen are ignored.

Lighting: Objects in the real world have their appearance shaped by the light sources in the scene. Lighting effects cause color shading, light reflection, shadows and other effects to be added to objects based on their position and the position of light sources in the room. Light sources can be anything from an overhead light in an internal room in an office (or castle) to the sun, moon, or even an explosion!

Texture Mapping: For realistic objects, it is necessary to overlay pictures on them to give them texture. For example, most walls are not made of a solid, flat substance. They are made of a material such as brick, wood or plaster, and they may have pictures, tapestry or signs on them. Texture mapping allows objects to be made so that they appear to have substance instead of being "flat". There are in fact several different types of texture mapping that are used by various software and hardware.

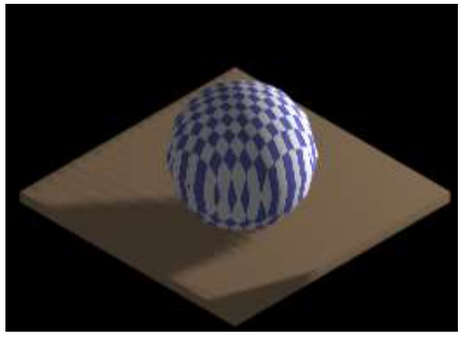

Fig. 2.41 *Texture mapping is done to the sphere. A spotlight is applied on the target sphere from the right side in a low ambient light condition. Photo-realistic rendering is then done with shadows enabled, using AutoCAD.*

NOTES

Transparency: Some objects in the real world are transparent or semi-transparent. Special calculations can be done to determine what objects are visible through a glass door, for example.

Fogging: An effect used in outdoor scenes, fogging serves two purposes by blurring objects that are in the distance. First, it helps to make the scene appear more realistic. If you've ever looked at a mountain scene you know that in the distance, objects to appear fuzzy due to atmospheric moisture. Second, fogging allows the 3D process to be performed more quickly because those objects in the distance that are "fogged out" can be computed more quickly since they are shown in less detail.

Filtering: There are several types of filtering that can be applied to the image. These are used to "clean up" the image and smooth out textures and shapes. In particular, bilinear filtering is used when showing textures up close to remove the "blocky" look that results from magnifying an object when showing it at the front of a scene.

Dithering: This is an effect that is actually used in many different places, including regular 2D graphics and also in printing. In 3D, it is used largely to show more realistic color without needing to increase the color depth of the image (which means saving both computation time and memory). Let us now explain the basic concept and techniques of dithering.

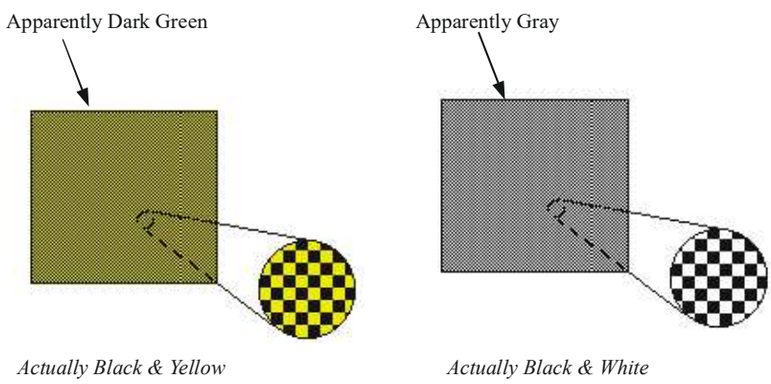

Fig. 2.42

We know that to represent real world objects on a computer screen we need to have a 'True Color' graphic system capable of displaying 16777216 (16 million) different colors. But when not so many different colors are available in the system a technique may be adopted to render images with colors which are apparent, non-existing actually. This technique known as ***Dithering*** is used in computer graphics to create the illusion of additional colors on a color display or printer. When our visual systems are confronted with large regions of high-frequency color changes they tend to blend the individual colors into uniform color field. Dithering attempts to use this property of perception to represent colors that cannot be directly represented.

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Traditionally, ***Halftoning*** is the process of printing continuous tone images (with multiple levels of gray or color) in newspapers, magazines and books using a bi-level printer. In case of black & white printing one cannot directly print lots of shades of gray using only pure black ink on a printing press. What it does actually is, it creates a dot pattern by exposing a negative through a fine screen (a halftone screen) onto a photosensitive printing plate. The size of the dots varies depending on the fineness of the screen and length of exposure. In areas where the image was dark, the plate would print large dots of ink – so large and dense that the dots may even overlap. In areas where the image was light, only the smallest dispersed dots of ink are printed. The dots fuse together, both on the paper and in our eye, to give a convincing illusion of continuous tones. Such printed images made up of a series of varying size & varying density dots in a specific pattern to simulate the look of continuous tones are commonly known as ***halftones***. Similarly *color halftones* are actually made up of a series of dots in Cyan, Magenta, Yellow, and Black (**CMYK**) that fools the eye into seeing the millions of colors that make up the original image. In this case there are four separate halftone screens, which are then superimposed on each other in each of the four colors.

Fig. 2.43 *This is the original grayscale image*

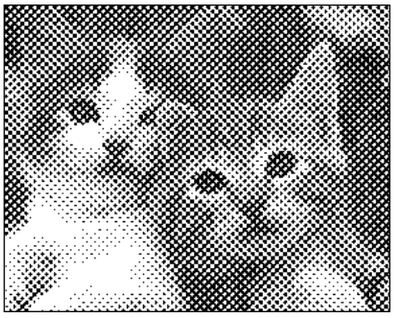

Fig. 2.44 *This is the B & W halftone of the original image*

See figures 9.43 and 9.44. This is how we view pictures in newspapers. As you hold your book farther from your eyes this image becomes clearer. Hold close and the individual halftone dots are visible. The shade of black is actually the same for the large and small dots but the smaller dots look like they are a lighter shade of gray than the larger ones. Note too that the dots are laid out in a diagonal pattern (at 45 degrees) rather than in horizontal rows and vertical columns. This is supposed to make the pattern a bit less noticeable to the human eye.

In computer graphics, ***Digital halftoning*** is adopted to simulate the traditional halftoning process. In this process an image is decomposed into a grid of halftone cells. Each such cell treated as a megapixel is a small two-dimensional array of actual pixels. The number and pattern of pixels turned on or off in them determine the gray value of the resulting picture element. The more number of off pixels in a halftone cell, the darker the cell appears.

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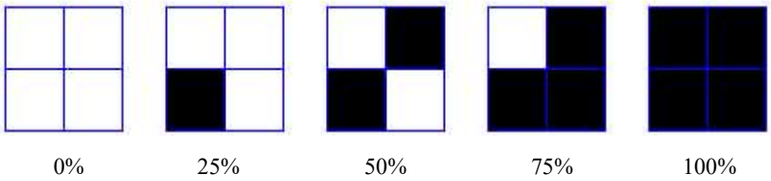

Fig. 2.45 *A 2 by 2 pixel grid used to display five gray shades on a bilevel digital system. As the pixels are darkened from left to right, the gray level of the grid increases from 0% to 100%. When these patterns are printed close packed on white paper we get the following five shades.*

The number of intensity levels that can be displayed with this method depends on how many pixels are included in a megapixel array and how many basic intensities the system is capable of generating, per pixel. If the **megapixel** array size is 3 by 3 then 10 different gray shades can be displayed in a system, which is otherwise capable of generating only two basic intensities (B & W). The following figure 2.46 illustrates these 10 intensity levels.

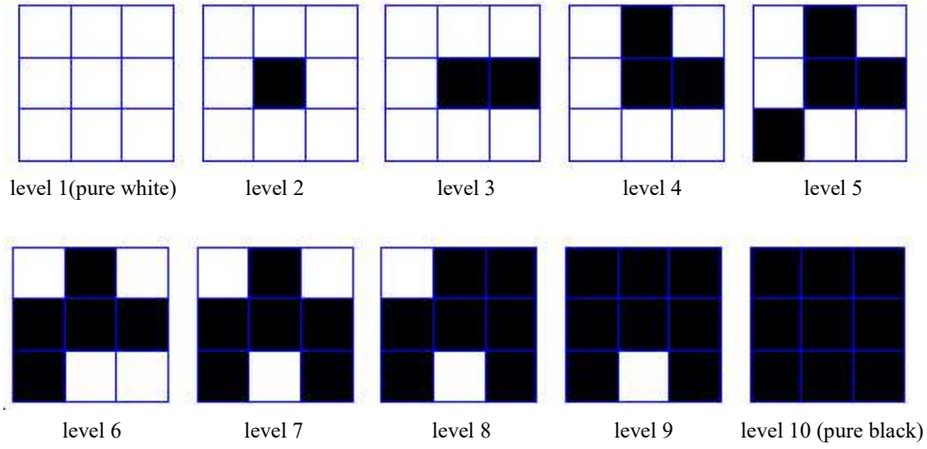

Fig. 2.46

In the above illustration, 'off' pixel positions are so chosen at each level that the resulting pattern approximates the increasing circle sizes used in halftone reproduction.

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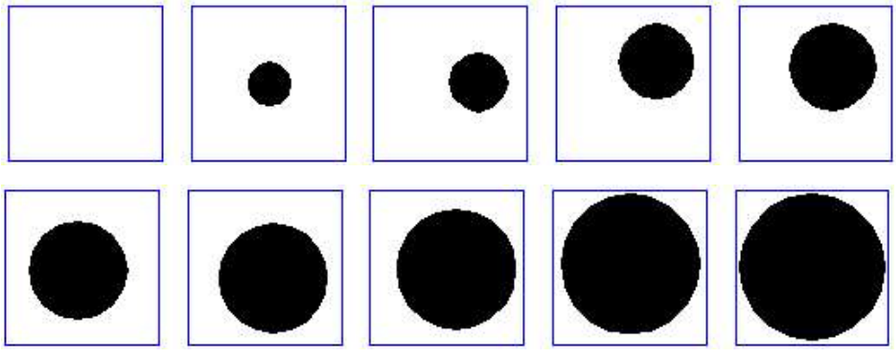

Fig. 2.47 *The halftone dot size increases as more number of pixels are set 'off' from level 1 to 10 as shown above*

Similarly for a 4 by 4 pixel grid we will get $4^2 + 1$ i.e. 17 different intensity levels. And generally speaking we get $n^2 + 1$ different intensity levels for an n by n array in a megapixel unit. However this is true for a bilevel (color depth 1) system only. If instead a multilevel or color display (color depth x, $x > 1$) system is used the halftone cell patterns will be bit more complicated. As an example the following figure depicts a possible set of patterns using 2 by 2 grid on a four-level ($x = 2$) system.

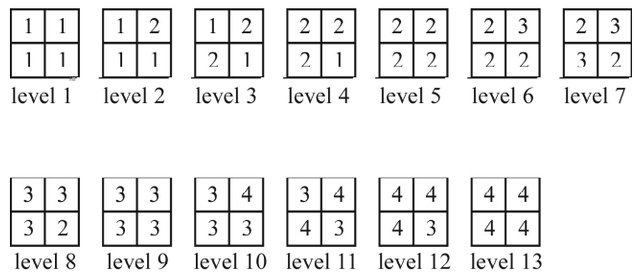

Fig. 2.48 *Four basic pixel-intensities are depicted by the numbers 1, 2, 3, 4. There are 13 combinations of these 4 intensities thus yielding 13 different megapixel-intensity. Observe the patterns and you will discover that pixel intensity values are enhanced following the order top-left, bottom-left, top-right then bottom-right as we move from level 1 to 13. This is done to minimize the visual artifacts associated with patterning. Patterns having multiple same intensity pixels along a horizontal or vertical line may result in streaks when a large area is shaded with it.*

While we attempt to increase the range of displayable intensity levels using megapixels we compromise with the image resolution at the same time. For a 2 by 2 square megapixel used we loose a factor of 2 resolution in both x and y axes. For resolution say, 800 by 600 pixels, 2 by 2 halftone reproduction of image would effectively reduce this resolution to 400 by 300 megapixels. The more gray levels you wish to display the larger the array necessary, and, therefore, the less resolution available. This is unlike the case of supersampling in Antialiasing where finer (smaller than the original) pixels or, the super pixels are used to calculate intensities.

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There are techniques, however, to improve the halftone approximations without loosing spatial resolution. These techniques often referred to as dithering techniques are presented below. Unlike patterning, dithering creates an output image with the same number of dots as the number of pixels in the source image.

Dithering Techniques

The simplest of the techniques is perhaps ***uniform quantization*** **or** ***thresholding***. In its simplest form of fixed thresholding the bitmap pixels are checked against a fixed intensity value (threshold). If the pixel intensity exceeds the threshold the corresponding image position is intensified, otherwise it is black. In multilevel thresholding different ranges of input intensity is converted to different fixed quantization or output intensity levels using separate threshold values for each range.

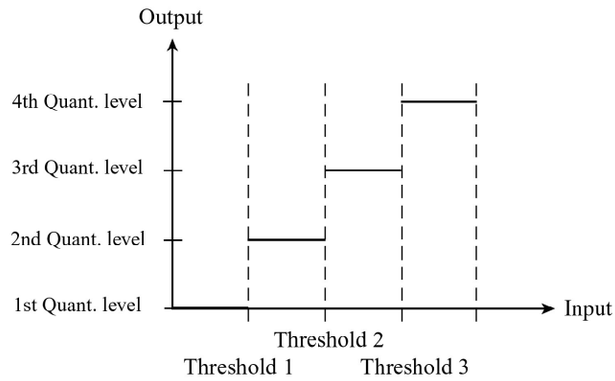

Fig. 2.49

Thresholded images are coarse approximations that occlude most of the nuances of the original images and are very unimpressive.

The next class of dithering, known as ***error diffusion*** approach distributes the quantization error for a pixel to its neighbouring pixels thus yielding a better reproduction of the original image compared to simple thresholding.

Fig. 2.50 *In the original grayscale image of the cats every pixel has a brightness value ranging from 0 (black) to 255 (white). 50% thresholding of the original image yields this pure B & W image. Any original pixel having value greater than or equal to 128 is set to white while those less than 128 is set to black.*

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In this approach the pixels of input image is scanned sequentially in raster scan pattern. Each pixel is compared to a threshold. If the pixel value is higher than the threshold, maximum intensity (white) is assigned, otherwise the minimum (black) is assigned. The error – the difference between the input pixel value and the output value – is dispersed or diffused to the nearby unquantized neighbour pixels as governed by the error filter. Thus the quantization error is used to modify the surrounding yet to be considered input values so as to preserve the inherent nuances of the image to some extent.

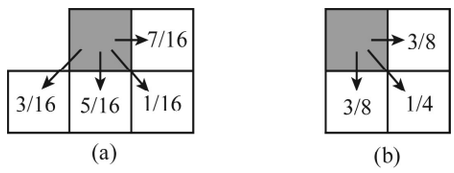

Fig. 2.51

This algorithm was first introduced by Floyd and Steinberg. According to *Floyd and Steinberg* ***Error Diffusion Algorithm*** the error is distributed downward and to the right i.e. in the direction of raster scan; 3/8 th of the error (of pixel at, say, (x, y)) is donated to the next right pixel (at $(x + 1, y)$), 3/8 th to the next downward pixel (at $(x, y + 1)$) and 1/4 th to the down-right diagonal pixel (at $(x + 1, y - 1)$.

(a) A common error diffusion filter that produces fairly good result

(b) **Floyd and Steinberg** error diffusion filter

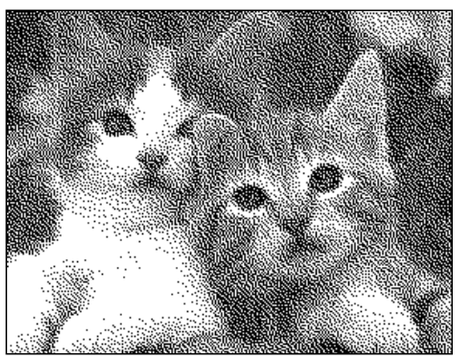

Fig. 2.52 *This is an error diffused dithered image from the original image. Threshold value 128 is used as before. Error diffusion tends to create 'streaking' artifacts known as worm patterns.*

It is evident that the quantization error is dependent upon the input signal. If one reduces the signal dependence of the quantization error, the visual quality of the binary image will be enhanced.

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One method of reducing this signal dependence is to add uniformly distributed **white noise**[9] to the input image prior to quantization. To each pixel of the grayscale image a random number n in the range [-A, A], which may be [-128,128] for a particular case, is added and then the resultant image is quantized by a 1 bit quantizer as done for simple thresholding. This method is known as ***random noise*** *dithering* or simply ***random dithering***.

Adding a completely random noise may eliminate some dithering artifacts such as *false contouring* but the visual impact is not pleasing to the eye.

Another improved technique of dithering known as ***ordered dithering*** optimizes the side effects of **quantization** against visual resolution. Ordered dithering produces a pattern that is predetermined and specific. The technique basically consists of comparing blocks of the original image with a 2D grid, known as a ***dither pattern***. Each element of the block is then quantized using the corresponding value in the dither pattern as a threshold. The values in the dither matrix are fixed but are typically different from each other. Because the threshold changes between adjacent pixels some decorrelation with quantization error is achieved, which minimizes some of the disturbing visual effects. Though higher order dither matrices can be generated using standard recursive functions, a simple 2 by 2 ordered dither- pattern matrix may be defined as,

$D_2 = \begin{pmatrix} 3 & 1 \\ 0 & 2 \end{pmatrix}$; to achieve 2^2 intensity levels this matrix produces patterns as shown before in case of digital halftone patterning.

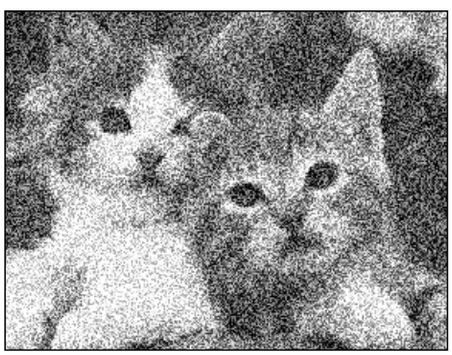

Fig. 2.53 *Random noise dithering example*

The image being much larger than this dither matrix, it is repeated or tiled across the full image in a raster order. While doing so each input intensity $I(x, y)$ is first scaled to the range 0 to 4. Next we determine the position (i, j) in the dither matrix corresponding to (x, y) pixel position by using a simple mod function as, $i = (x \bmod 2) + 1$ and $j = (y \bmod 2 + 1)$; now scaled $I(x, y)$ is compared to the

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corresponding element $D_2(i,j)$ of the dither matrix and the output intensity $O(x, y)$ is set as per the thresholding rule as,

$$O(x,y) = \begin{cases} \text{Black, if } I(x,y) < D_2(i,\ j) \\ \text{White, else} \end{cases}$$

Similarly a 3 by 3 dither matrix, $\begin{pmatrix} 7 & 2 & 6 \\ 4 & 0 & 1 \\ 3 & 8 & 5 \end{pmatrix}$ can be used to achieve 9 intensity levels, and so on.

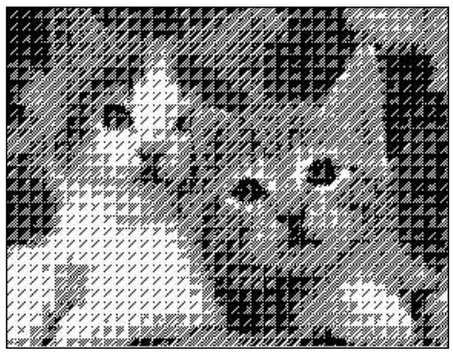

Fig. 2.54 *Ordered dithering using 8 by 8 pattern matrix*

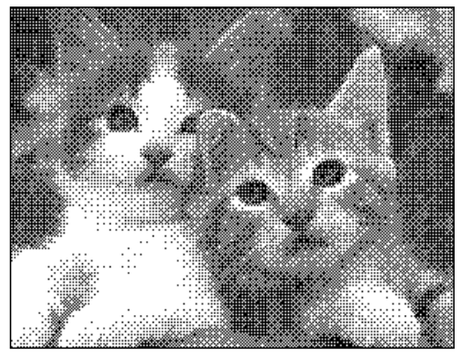

Fig. 2.55 *A finer ordered dithering – probably the best of the lot*

You may try out some dithering exercises on a grayscale picture in *Adobe Photoshop*. All the examples shown here are done in Photoshop. You can even create your own custom dither pattern for a selected RGB color using *DitherBox* in Photoshop and apply the same in other images. It is really interesting.

2.3.5 Image Editing and Modeling Softwares

Among a wide variety of Image Processing softwares now available in the market, a few of them have become industry standards like *Adobe Photoshop*, *Aldus Photostyler* and *Paint Shop Pro.* Some other useful packages of that kind are *Fractal Designs Painter, Uleads PhotoImpact* and *PhotoExpress, Picture Publisher* etc. The Windows *Paint* accessory provides rudimentary bitmap editing and painting.

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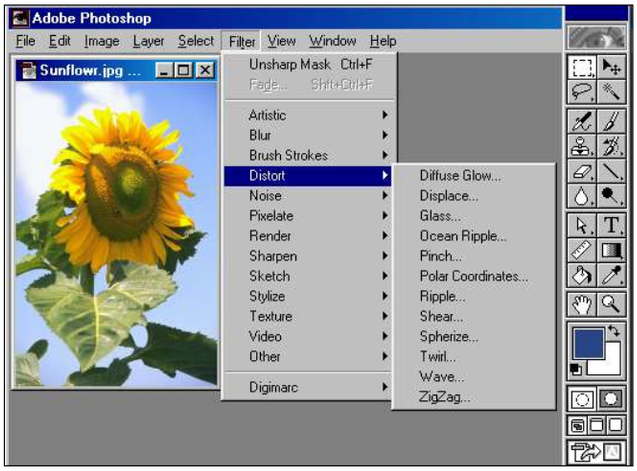

Fig. 2.56 *Adobe Photoshop: recognized as one of the world-standard image-editing solution in the market today. It can open and edit a wide variety of digital images – images created in Photoshop or another software or scanned photographs. Photoshop's core set of image-editing tools help you mask complex images and provides a comprehensive environment to expand your creative power with the most powerful painting and special effect tools. Its cutting-edge web features, lets you create dynamic web graphics and web animations also.*

Today bitmaps are used in multimedia more often than vector drawn objects. Because bitmapped images, typically, provide the greatest choice and power to the professional designers for rendering fine detail and effects. Yet packages like *CorelDraw, FreeHand, Illustrator, Designer* and *Canvas*, dedicated to producing vector-based line art, are still popularly used in the DTP industry.

Powerful modeling packages with improved GUI are increasingly entering the mainstream of graphic design and multimedia production. Some of the best softwares widely used by multimedia developers are *AutoDesk's 3D Studio Max* and *AutoCAD, Macromedia's Extreme 3D, 3D Home Architect* etc.

Fig. 2.57 *AutoCAD: Still the market leader in CAD softwares. Features powerful solid modeling and rendering tools, illumination control, texture mapping etc. The vector-based drawings are created through intuitive commands or AutoLISP codes*

NOTES

Check Your Progress

1. Why are input devices used?
2. How are the keyboard devices classified?
3. Define the term mouse.
4. Where are the touch pads usually used?
5. State the significance of scanning devices.
6. Where is magnetic ink character usually used?
7. What does a digitizer consist of?

2.4 VIDEO DISPLAY

Graphics capabilities for both two-dimensional and three-dimensional applications are now common in general-purpose computer applications, including many hand-held tools like calculators. Graphics users can use a wide variety of interactive input devices and graphics software packages with personal computers. They can choose from a number of complicated special-purpose graphics hardware systems (like track ball and plotters) and technologies for higher quality applications.

2.4.1 Video Display Devices

There are various types of video display devices some of them have been discussed in this section.

Refresh Cathode-Ray Tubes (CRTs)

A cathode ray tube is frequently called a CRT. A CRT is an electronic display device in which an electron beam can be focused on a phosphorescent viewing screen and speedily varied in position and intensity to produce an image. The best known application of a CRT is as a picture tube in all commercially available televisions. Other applications include radar screens, oscilloscopes, flight simulators, embedded systems, and computer monitors.

A cathode-ray tube consists of three basic parts: the glass wrapper, the phosphor viewing surface, and the electron gun assembly. The electron gun assembly consists of a heated metal cathode enclosed by a metal anode. The anode is given a positive electrical voltage and the cathode is given a negative electrical voltage. There is a flow of electrons from the cathode through a small nozzle in the anode that produces a beam of electrons. The electron gun contains electrical plates or coils which focus, accelerate, and redirect the electron beam to strike the phosphor viewing surface in a quick side-to-side scanning motion starting at the top of the surface and working downwards, repeating the same process. The phosphor viewing surface is a thin layer of material through which visible light is emitted

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when hit by the electron beam. The colour on the display unit is determined by the chemical composition of the phosphor and can be altered by changing its composition. The glass wrapper consists of a relatively flat face plate (horizontal and vertical), a neck section, and a funnel section. The electron gun assembly is packed into the glass neck at the opposite end. The phosphor viewing surface is deposited on the inside of the glass plate. The function of the funnel is to place the electron gun at an appropriate distance from the plate and to grip the glass envelope together so that a vacuum can be achieved inside the tube.

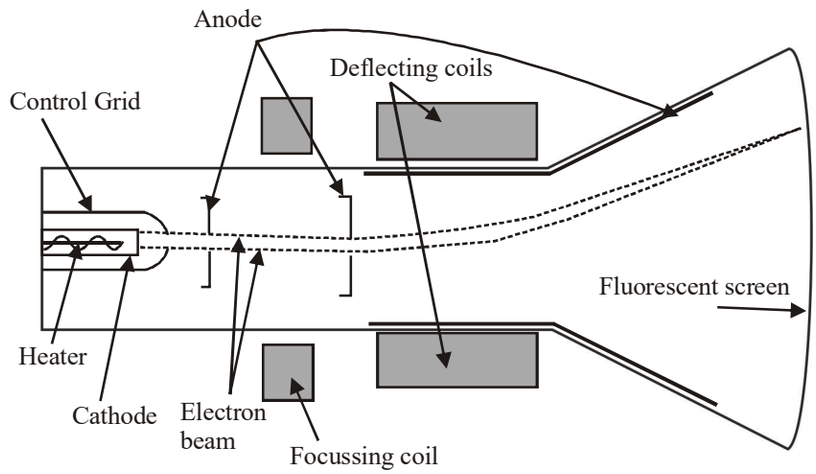

Fig. 2.58 *A Cathode Ray Tube*

A cathode-ray tube, used in a colour computer monitor or colour television, has a few additional parts. There are three electron guns instead of one electron gun in general, one for the red colour signal, one for blue, and one for green. Also three different phosphor materials are used on the display surface, one for each colour. A 63 Centimeters (25-inch) colour TV picture tube may have a shadow mask with 1.5 million individual phosphor dots and 500000 perforations.

Design of CRT

As a graphics application is initiated, the electron gun is programmed for each new graphics application. New screen sizes, new image resolution settings, and new overall glass envelope dimensions, all require a new electron gun design. New image resolution necessities may require a new technique of depositing the phosphor dots on the face plate. As a result it may require new material processing techniques. The amount of time the phosphors produce light or shine is controlled by the chemical composition of the phosphor. This phenomenon is known as *persistence*. In a colour television CRT, the electron beam scans the screen 25 times per second (as shown in figure 2.59). If the persistence is longer than one twenty-forth of a second, the image shows two scans at the same time and appears indistinct.

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2.4.2 Raster Scan Display

The most common type of graphics monitor, the raster scan, is based on television technology and uses a CRT. The electron beam in a raster scan system is swept across the CRT, one row at a time from top to bottom, as shown in Figure 2.59. The beam intensity is turned on and off as the electron beam moves across each row, to create a pattern of illuminated dots. The picture definition is saved in a memory area (called the *frame buffer*). The frame buffer holds the set of intensity values for all the screen points. The stored intensity values are then fetched from the refresh buffer and displayed on the screen one row at a time. The capability of a raster scan system to save intensity information for each pixel makes it more efficient for the practical display of scenes containing fine shade and colour patterns.

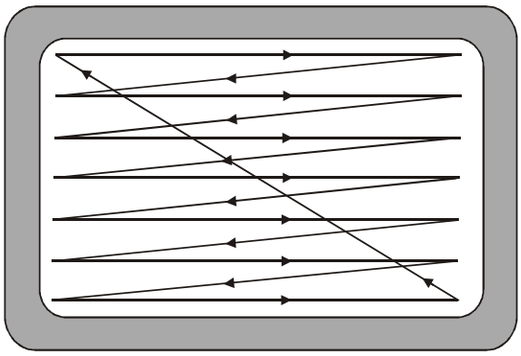

Fig. 2.59 *Raster Scan Display*

In a simple black-and-white system (one kind of monochrome screen), each screen point is either on or off. Thus, only one bit per pixel is needed to control the intensity of screen positions. A bit value of 1 indicates that the electron beam is to be turned on at that position for a bi-level system, and a value of 0 indicates that the beam intensity is off at that pixel position. Up to 24 bits per pixel may be included in high-quality systems, which can require several megabytes of memory for the frame buffer, depending on the resolution of the system. A system with 24 bits per pixel and a screen resolution of 1024 × 1024 requires 3 MB of storage for the frame buffer.

2.4.3 Random Scan Display

Basically there are two types of CRTs: raster scan type and random scan type. The main difference between the two is based on the technique with which the image is generated on the phosphor coated CRT screen. In raster scan, the electron beam sweeps the entire screen in the same way as you would write a full page text in a note book, word by word, character by character, from left to right and top to bottom. On the other hand, in random scan technique, the electron beam is directed at that point of the screen where the image is to be produced. It generates the image by drawing a set of random straight lines much in the same way one might move a pencil over a piece of paper to draw an image, drawing strokes from one

point to another, one line at a time. This is why this technique is also referred to as vector drawing or stroke writing or calligraphic display.

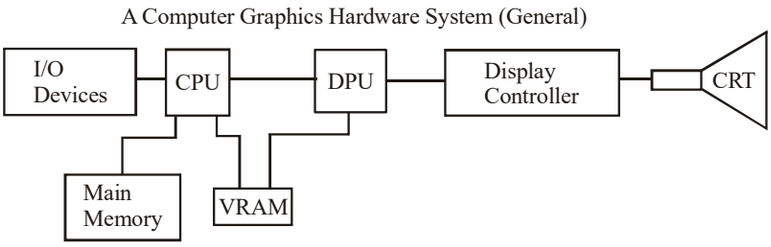

Fig. 2.60 *Block Diagram of Random Scan Display*

There are of course no bit planes containing mapped pixel values in the vector system. Instead the display buffer memory stores a set of line drawing commands along with end point coordinates in a display list or display program created by a graphics package. The Display Processing Unit (DPU) executes each command during every refresh cycle and feeds the vector generator with digital x, y, and x, y values. The vector generator converts the digital signals into equivalent analog deflection voltages. This causes the electron beam to move to the start point or from the start point to the end point of a line or vector. Thus the beam sweep does not follow any fixed pattern; the direction is arbitrary as dictated by the display commands. When the beam focus must be moved from the end of one stroke to the beginning of the other, the beam intensity is set to 0.

Though vector-drawn images lack in depth and colour precision, random displays can work at higher resolution than raster displays. The images of random display are sharp and have smooth edges unlike the jagged edges and lines on raster displays.

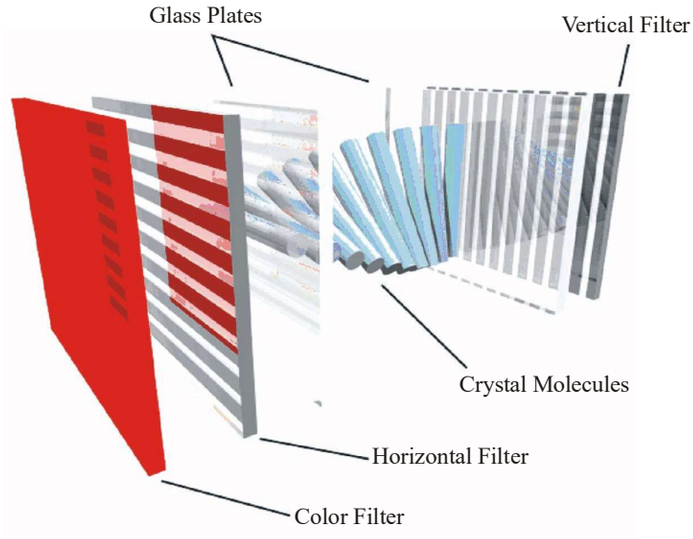

Fig. 2.61 *Functioning of LCD Display*

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2.4.4 Liquid Crystal Display (LCD)

LCD is the technology used for displays in notebooks, laptops and other smaller computers. Like gas-plasma technologies and Light-Emitting Diodes (LEDs), LCDs allow displays to be much thinner than CRT technology. The liquid crystal displays use much less power than LED and gas-display displays because they work on the principle of blocking light rather than its release.

A liquid crystal display can be made with either a passive or an active matrix display grid. The active matrix LCD is also called a Thin Film Transistor (TFT) display. The passive matrix liquid crystal display has a grid of conductor materials with pixels located at each intersection in the grid. A current can be applied across two conductors on the grid to control the light for any pixel. Some passive matrix liquid crystal displays have a double scanning mechanism. This means that they scan the grid with current to times in the same time that it takes for one scan in the original technology. However, active matrix technology is still a superior one.

2.4.5 Direct View Storage Tube

Direct View Storage Tube (DVST) is rarely used today as part of a display system. However, DVST marks a significant technological change in the usual refresh type display. Both in the raster scan and random scan system the screen image is maintained flicker free by redrawing or refreshing the screen many times per second. This is done by cycling through the picture data stored in the refresh buffer. In DVST there is no refresh buffer; images are created by drawing vectors or line segments with a relatively slow moving electron beam. The beam is designed not to draw directly on phosphor but on a fine wire mesh (called storage mesh) coated with dielectric and mounted just behind the screen. A pattern of positive charge is deposited on the grid, and this pattern is transferred to the phosphor coated screen by a continuous flood of electrons emanating from a separate flood gun.

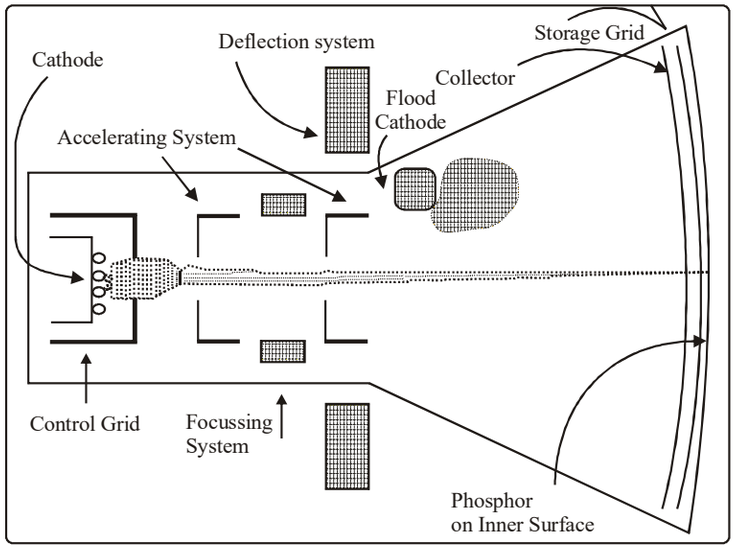

Fig. 2.62 Direct View Storage Tube (DVST)

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Just behind the storage mesh is a second grid, the collector. Its main purpose is to smooth out the flow of flood electrons. These electrons pass through the collector at a low velocity and are attracted to the positively charged portions of the storage mesh but repelled by the rest. Electrons not repelled by the storage mesh pass right through it and strike the phosphor.

To increase the energy of these slow moving electrons and thus create a bright picture, the screen is maintained at a high positive potential. The storage tube retains the image generated until it is erased. Thus no refreshing is necessary, and the image is absolutely flickering free.

A major disadvantage of DVST in interactive computer graphics is its inability to selectively erase parts of an image from the screen. To erase a line segment from the displayed image, one has to first erase the complete image and then redraw it by omitting that line segment. However, the DVST supports a very high resolution which is good for displaying complex images.

2.5 MORPHING

Though any type of image-update dynamics falls within the domain of animation, specifically, transformation of object shapes from one form to another is called morphing. This is an abbreviated form of metamorphosis – metamorphosis of images.

The contour and color of the image of a cat can morph into that of the image of a tiger through simple shape and color interpolation. Morphing effect can not only be applied in transition between still images but often between moving images as well. It can produce transformations from one object to a completely different object, like a racing motorcycle transforming into a speeding Cheetah. Or it can produce smooth transition from the original object to its distorted version – a smile created in a face, or, a structure buckled under load, or, something like that where the basic object remains same, only the character changes.

Fig. 2.63 *Morphing application: face of the lady sequentially transforming into the face of a lion*

There are two parts in the morphing algorithm – the warp and the dissolve. Given a source image and a target image, ***warping*** is the process of distorting the source image so that it matches the target image. Actually enough number of ***feature***

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points or ***morph points*** is specified on both the source and target image that defines the respective profile features and divides the images in non-overlapping triangular and quadrangular meshes. Warping forces morph points of the two different images match up at the end. This in turn produces one-to-one transformation of mesh triangles and quadrangles of the source and target images.

For a morph point A in the source image and a corresponding morph point B in the target image linear interpolation is used to generate a new morph point C in an intermediate image. It is given as C = wA + (1 – w)B, w being a weight applied based on the position of the intermediate image in the timeline. The linear transformation between two triangles, say, ABC and XYZ in the source and target images respectively are given by,

$\mathbf{p} = w_1\mathbf{A} + w_2\mathbf{B} + w_3\mathbf{C}$ [**p** is the position vector of any pixel within DABC]

$\mathbf{p}' = w_1\mathbf{X} + w_2\mathbf{Y} + w_3\mathbf{Z}$ [**p′** within DXYZ is the transformed counterpart of **p**]

$w_1 + w_2 + w_3 = 1$

Thus morphing is a kind of shape-tweened animation. There are dedicated morphing softwares available in the market where the basic keyframing technique applied is same as that adopted in animation ***(motion tweening)*** softwares.

At first you should have the image of the original object as the first keyframe (source image) of the morphing sequence. Then you create a second keyframe the desired number of frames after the first frame. Here you copy the original object, or, put a completely different object. This would be the last frame (target image) in the sequence depicting the ultimate transformation stage. Set equal number of morph points (keypoints) in the first and last keyframes to specify the changes of different portions of the image separately. As morph points have a one-to-one correspondence in starting and ending shapes the point you set in the start image will move/change to the corresponding point in the end image.

Thus you can position morph points along the contour of lips, both in the image of a face (in the start keyframe) and in its copy (in the end keyframe). If you want to make the face smiling you have to open up the lips. So reposition the morph points along an imaginary open-lip contour in the end frame assuming how it should appear after the original face gets changed to a smiling face. The software will now interpolate the shapes for the frames in between, thereby creating the desired morphing. The more the number of morph points and intermediate frames chosen (with a given frame rate), the smoother the morph will be. Similarly you can morph the image of a girl into the image of a boy. The effect will be as if the girl is gradually transforming to a boy miraculously by some magic-touch.

Actually when the morphing routine is run the image of the start frame is warped[13] into the shape of the end frame image as it gradually fades away. At the same time that the is undergoing the fading and warping effect, the target image is

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undergoing the reverse warping and **fading**. That is, the target image gradually fades in and reveals itself most prominently in the end frame. Good morphing software provides so smooth blending of two images that the source image seems to melt or dissolve into the subsequent image frames and finally to the target image. This part of morphing process is known as ***dissolve***. While warping creates transformation between point coordinates, dissolve causes transformation of color vectors (R, G, B) pixel by pixel.

For some control over the software-generated morphing sequence, you can choose an option for **blend type**:

Distributive type creates a sequence in which the intermediate shapes are smoother and more irregular.

Angular type creates a sequence that preserves apparent corners and straight lines in the intermediate shapes. Angular is appropriate only for blending shapes with sharp corners and straight lines.

As in motion tweening, the rate of shape-transition can be controlled in a morphing sequence. By default, the rate of shape change through tweened frames is constant. Easing (In & Out) creates a more natural effect of morphing by increasing or decreasing the rate of change toward the beginning or ending of a transition.

The following example is easy to understand how shape change occurs in morphing.

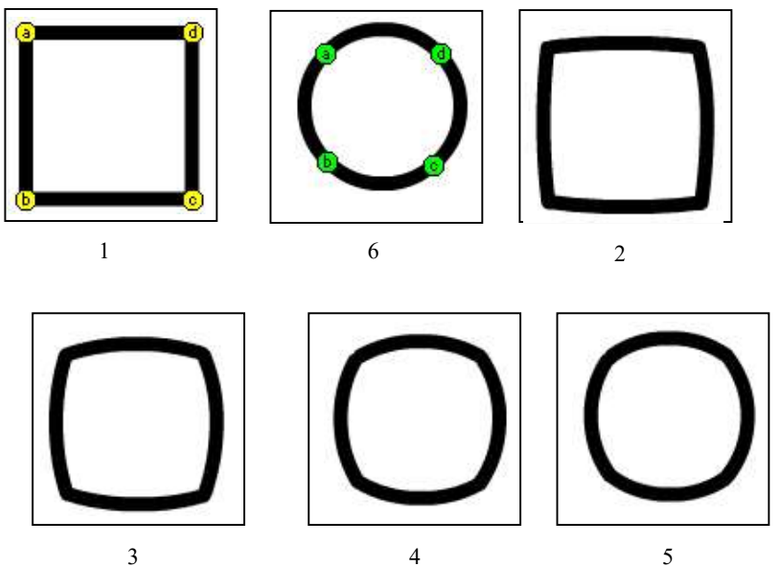

Fig. 2.64 *Frame 1 is the start frame showing morph points a, b, c, d on the square. Frame 6 is the end frame showing the changed position of the same set of morph points on the circle. We want the square to transform to the circle. Frames 2-5 are the intermediate frames generated by the software as the square gradually fades out and the circle takes its shape.*

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Today some of the most widely used tools for creating multimedia animations are *Macromedia's Director* (dir) and *Flash* (), *AnimatorPro* (fli and flc), *3D Studio Max* (max), *Shockwave* (dcr), etc. Within brackets we have specified the animation file formats generated by the corresponding software. Besides this, Windows Audio Video Interleaved *format* (avi), mpg and mov formats can also contain animations.

Some products that offer morphing features are *Gryphon Softwares Morph*, *Ulead's MorphStudio, ImageWare's MorphWizard, MetaTool's Digital Morph*, etc.

2.6 DEVICE DRIVERS

A device driver is a program which controls a particular type of device that is attached to your computer. It allows high level programs to interact with a hardware device. There are device drivers for printers, displays, CD-ROM readers, diskette drives, etc. When you buy an operating system, many device drivers are built into the product. However, if you later buy a new type of device that the operating system does not anticipate, you will have to install the new device driver. A device driver essentially converts the more general I/O instructions of the operating system to messages that the device type can understand. Some Windows programs are virtual device drivers. Figure 2.65 displays the structure of system call interface which has divided into three parts, known as memory management, file system and process management. Block I/O and Character (Char) I/O are the two parts of file system which are connected to various device drivers. In kernel, a file is represented by a data structure called an index-node or inode.

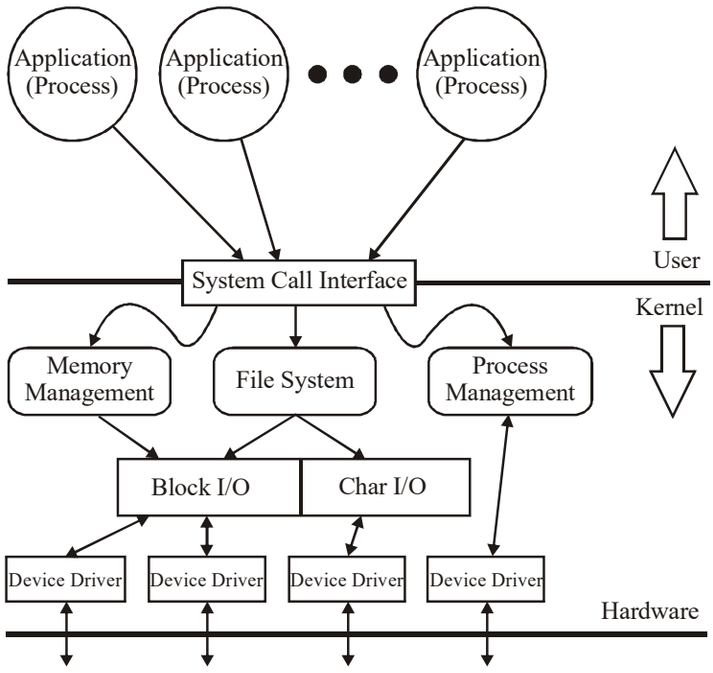

Fig. 2.65 *Structure of System call Interface*

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These programs are interfaced with the Windows Virtual Machine Manager (VMM). There is a virtual device driver for each main hardware device in the system including the hard disk drive controller, keyboard and serial and parallel ports. They are used to maintain the status of a hardware device that has changeable settings. Virtual device drivers handle software interrupts from the system rather than hardware interrupts. In Windows operating systems, a device driver file usually has a file name suffix of Dynamic Link Library (DLL) or Executable (Exe). A virtual device driver usually has the suffix of Virtual eXtended Device (VXD). Each controller has some device registers used to give it commands or some device registers used to read out its status or both. The number of device registers and the commands vary from device to device. For example, a mouse driver has to accept information from the mouse telling how far it has moved and which buttons are currently pressed. In contrast, a disk driver has to know about sectors, tracks, cylinders, heads, arm motion, motor drives, head settling times, and all the other mechanics of making the disk work properly. As a consequence, each I/O device attached to a computer needs some device specific code for controlling it. This code, called the device driver, is generally written by the device's manufacturer and delivered along with the device. Since each operating system needs its own drivers, device manufacturers commonly supply drivers for several frequently used operating systems. Each device driver normally handles one device type. For example, a Small Computer System Interface (SCSI) disk driver can usually handle multiple SCSI disks of different sizes and different speeds and perhaps a SCSI CD-ROM as well. On the other hand, a mouse and joystick are so different that different drivers are usually required. However, there is no technical restriction on having one device driver control multiple unrelated devices. In order to access the device hardware and controller registers, the device driver normally has to be part of the operating system kernel with current architectures. Device drivers are normally positioned below the rest of the operating system as illustrated in Figure 2.66.

Operating systems usually classify drivers into one of the small number of categories. The most common categories are the block devices (disks) which contain multiple data blocks and can be addressed independently with the character devices (keyboards and printers) generate a stream of characters. Most operating systems define a standard interface supporting all block drivers and a second (alternate) standard interface supporting all character drivers. These interfaces consist of a number of procedures that the rest of the operating system can call to get the driver to work for it. Typical procedures are those to read a block (block device) or write a character string (character device). In some systems, the operating system is a single binary program that contains all of the drivers for compiling. If a new device is added, the system administrator simply recompiles the kernel with the new driver to build a new binary. A device driver has several functions. The most obvious one is to accept abstract read and write requests from the device independent software and check whether they are carried out while performing the operations. But, there are also a few other functions they must perform. For example, the driver must initialize the device, if needed. It may also need to manage

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its power requirements and log events. Drivers are not allowed to make system calls but they often need to interact with the rest of the kernel. Usually, system calls to certain kernel procedures are permitted. For example, there are usually calls to allocate and deallocate hardwired pages of memory for use as buffers. Other useful system calls are needed to manage the Memory Management Unit (MMU), timers, the Direct Memory Access (DMA) controller and the interrupt controller.

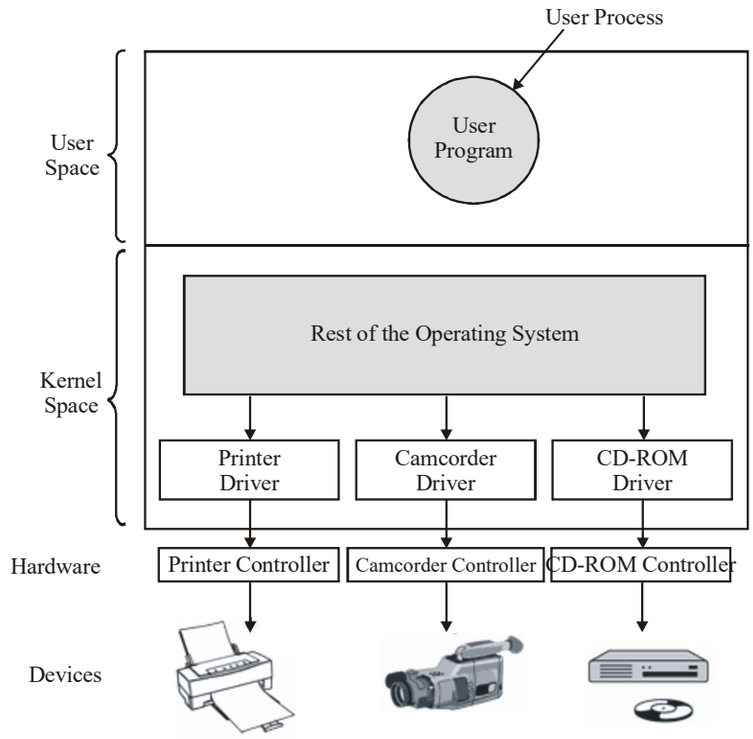

Fig. 2.66 *Position of Device Driver in Operating System*

A driver is a program that extends the kernel's functionality. There are many different drivers in the kernel which provide support for hardware devices, file system types, binary executable formats, network protocols, etc.

The bulk of the kernel binary, which exists both as a disk file `(/boot/vmlinuz` or `/boot/vmlinux`) and as memory at run time, is made up of drivers (refer Figure 2.67).

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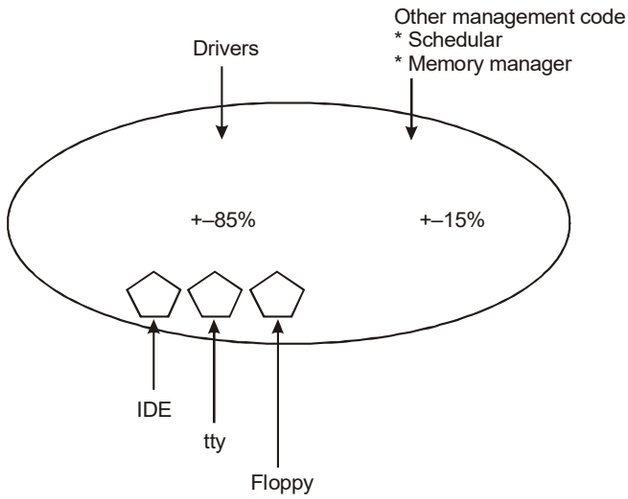

Fig. 2.67 *Kernel Binary*

2.6.1 Driver Types

There are two types of drivers:

- Internal drivers
- External drivers

Internal drivers are a part of the kernel memory and thus also a part of the kernel binary. External drivers are not a part of the kernel memory and are loaded into the user memory when required.

External drivers are also known as loadable kernel modules and exist as disk files, stored under `/lib/modules`. These can be loaded into the user memory when required and unloaded when no longer required.

2.6.2 Implementation of Drivers

Internal drivers come only with UNIX and that also up to SVR3, as we know that internal drivers are a part of the Kernel binary. The vendor ships all the drivers and other kernel components as pre-compiled binary files located on the installed filesystem.

If a new hardware has to be installed to the system, for example, a SCSI controller, then as a process a new kernel binary has to be built that will incorporate the appropriate driver for the device. Normally, the driver is either supplied by the UNIX vendor or is a third party driver supplied by the hardware vendor of the device.

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The installation script normally creates an appropriate device file in the **/dev** directory from where the programs can access the hardware with normal file access system calls. The calls are like `open(), close(), read(), write()`. This installation script is supplied by the third party vendor, or in the case of generic drivers, by the UNIX vendor. After this the system has to be rebooted so that the new kernel can run, with the appropriate driver. This new kernel will now be able to communicate with the respective device.

The concept of loadable modules was introduced from System V Release 4(SVR4) later Berkeley Software Distribution (BSD) and Linux also follows the same design model. However every UNIX system uses different commands to manage these.

Check Your Progress

8. What is a cathode-ray tube?
9. What does a cathode-ray tube consist of?
10. Define the term raster scan.
11. State the significance of LCD technology.
12. Define the term morphing.

2.7 SPEECH RECOGNITION

Speech recognition, often known as speech-to-text, is the capacity of a machine or programme to recognise and transform spoken words into legible text. Only a small number of words and phrases are recognised by rudimentary voice recognition software, and it can only do so if they are uttered very clearly. More advanced software can recognise natural speech, as well as distinct accents and languages. Speech recognition technology is a form of technology that enables a computer to recognize and translate the words spoken into a microphone into written text. As a result, speech recognition is also known as speech-to-text. Speech recognition technology is a kind of technology that provides a communication between a man and machine. The speech recognition engine's main task is to process spoken input and convert it into text that an application can understand.

The analysis of the human voice for means of human-computer interaction is a separate approach that has been thoroughly investigated. Even though voice processing and more precise speech recognition have been known since the 1960s, mobile devices have only lately gained sufficient processing power and storage to do speech processing.

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2.7.1 Techniques of Speech Recognition

Speech recognition is works using acoustic and linguistic modelling techniques. Language modelling aligns sounds with word sequences to help discriminate between words that sound similar; acoustic modelling represents the relationship between linguistic units of speech and audio signals.

There are various types of speech recognition:

- Isolated Words
- Connected Words
- Continuous Speech
- Spontaneous Speech

Isolated Words

Isolated word recognizers usually require each utterance to have quiet (lack of an audio signal) on both sides of the sample window. It accepts single words or single utterance at a time. These systems have "Listen/Not-Listen" states, where they require the speaker to wait between utterances (usually doing processing during the pauses). Isolated Utterance might be a better name for this class.

Connected Words

Connected word systems are similar to isolated words but allows separate utterances to be 'run-together' with a minimal pause between them.

Continuous Speech

Continuous speech recognizers allow users to speak almost naturally, while the computer determines the content. Recognizers with continuous speech capabilities are some of the most difficult to create because they utilize special methods to determine utterance boundaries.

Spontaneous Speech

At a basic level, it can be thought of as speech that is natural sounding and not rehearsed. An ASR system with spontaneous speech ability should be able to handle a variety of natural speech features, such as words being run together, 'ums' and 'ahs', and even slight stutters.

2.7.2 Applications of Speech Recognition

The most frequent applications of speech recognition within the enterprise include the use of speech recognition in mobile devices. For example, individuals can use this functionality in smartphones for call routing, speech-to-text processing, voice dialling and voice search.

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Without having to look down at their phone, a smartphone user could answer to a text using the speech recognition feature. On iPhones, for example, speech recognition is linked to other features like the keypad and Siri. Speech recognition can also be found in word processing applications like Microsoft Word, where users can dictate what they want to show up as text.

Advantages of Speech Recognition Technology

Speech recognition technology, though helpful, still has a few difficulties to sort out as it develops. Speech recognition software has the advantages of being simple to use and easily available. Speech recognition software is now commonly installed in computers and mobile devices, making it simple to use.

Some key advantages are,

- It makes human and computer interaction simple and useful.
- It is also help for people who cannot use a keyboard .
- The technology is useful if user's hands are occupied.

Disadvantages

Speech recognition has several drawbacks, including the failure to catch words in some cases due to variances in pronunciation, the absence of support for some languages, and the inability to sort through background noise. Inaccuracies may result because of these variables. Some voice recognition software may also take a long time to process speech and appear to be slow.

Some key disadvantages are,

- The voice recognition is difficult noisy environment.
- Sometimes speech patterns are slower throughput than with typing.
- Sometimes they are recognizing boundaries between spoken words.

2.8 HANDWRITING RECOGNITION

Handwriting recognition refers to a computer or mobile device's capacity to recognize handwriting as text. Handwriting recognition as a direct input to a touchscreen through a pen or finger is the most popular use case in today's mobile world. Handwriting recognition refers to a computer's or device's ability to take handwriting as input from sources, such as written physical documents, photographs, and other devices, or to use handwriting as a direct input to a touchscreen and then interpret it as text is a computer's ability to recognise and interpret intelligible handwritten input from various sources.

The input is usually in the form of an image, such as a photograph of handwritten text that is fed into pattern-recognition software, or real-time recognition using an optical scanner.

The most widely used technique for handwriting recognition is Optical Character Recognition (OCR). This is achieved by scanning and converting a handwritten document into a plain text document.

Challenges in Handwriting Recognition

Handwriting recognition tends to have problems when it comes to accuracy. People can **struggle to read others' handwriting**. The problem is that there are many different types of handwriting, both good and bad. This makes it difficult for programmers to provide sufficient samples of how each character could appear. Furthermore, characters might appear quite identical at times, making it difficult for a computer to recognise them effectively.

Techniques of Handwriting Recognition

Machine Learning methods, such as Hidden Markov Models (HMM), SVM, and others were used in the early attempts to solve handwriting recognition. After the initial text has been pre-processed, feature extraction is used to detect crucial information about each character, such as loops, inflection points, aspect ratio, and so on.

2.9 SPEECH GENERATION

Speech is the oldest ways for humans to exchange information. Attempts to develop vocally interactive computers to realize voice/speech synthesis have been made over the years. Clearly, such an interface would be extremely beneficial. A computer should synthesise text and deliver a speech in this case. Speech Generation is the process of generating speech from other sources such as text, lip movements, and so on. Speech is a highly specialised and skill-intensive discipline that requires extensive training. Speech generation helps in combining the text is many navigation systems, games, cockpits and control rooms and other control room applications. Its speech involves cognitive load so need to be used carefully. Text-To-Speech (TTS) is one application. Speech input can be done with the help of Automatic Speech Recognition (ASR). It is helpful in dictation, subtitles, call centres, translation, meeting minutes, computer games. Speech output can be done with the help of Text-To-Speech synthesis (TTS). It is helpful in system response, screen reader for the blind, car navigation systems, directory assistance, toys, computer games.

The main objectives of speech generation are:

- Conversion of voice.
- Speech to speech translation.
- Spoken dialogue system.
- Used in education.
- Used in therapy.

- Helps in noise cancelling.
- Helps in speech enhancement.

Applications of Speech Generation

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• Unified Messaging

One of the most appealing applications is unified messaging. It combines voicemail and email into a single unified mailbox that can be accessed via regular email programmes, the Web, and the phone.

• Reading of Web Pages

The reading of Web pages is another application. Special text filters extract the information sought through the web and provide the appropriate text to the TTS system, which then presents the message by speech, like how email reading works.

• Augmentative Communication

The term 'Augmented Communication' refers to the use of technology to make personal conversation easier. It would be beneficial if someone who is unable to speak for one reason or another could utilise a device through which he or she may define utterances or converse with another person. Because the voice is being replaced, the obvious means of communication for such a device is (synthetic) speech.

Check Your Progress

13. What is a device driver?
14. State the role of a driver program.
15. Differentiate between external and internal drivers.

2.10 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Input devices are used to transfer user data and instructions to the computer.
2. Keyboard devices are typically classified as general-purpose keyboards and special-purpose keyboards.
3. A mouse is a small input device used to move the cursor on a computer screen to give instructions to the computer and to run programs and applications. It can be used to select menu commands, move icons, size windows, start programs, close windows, etc.
4. Touch pads are mostly found in notebooks and laptops where convenience, portability and space are the prime design concerns.

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5. Scanning devices are input devices used for direct data entry from the source document into the computer system.
6. Magnetic ink character recognition is like an optical mark recognition device and is used only in the banking industry.
7. A digitizer consists of a digitizing or graphics tablet, which is a pressure-sensitive tablet, and a pen with the same X and Y coordinates as on the screen.
8. A cathode-ray tube is frequently called a CRT. A CRT is an electronic display device in which an electron beam can be focused on a phosphorescent viewing screen and speedily varied in position and intensity to produce an image.
9. A cathode-ray tube consists of three basic parts: the glass wrapper, the phosphor viewing surface, and the electron gun assembly.
10. In raster scan, the electron beam sweeps the entire screen in the same way as you would write a full page text in a notebook, word by word, character by character, from left to right and top to bottom.
11. LCD is the technology used for displays in notebooks, laptops, and other smaller computers. Like gas-plasma technologies and Light-Emitting Diodes (LEDs), LCDs allow displays to be much thinner than CRT technology.
12. Though any type of image-update dynamics falls within the domain of animation, specifically, transformation of object shapes from one form to another is called morphing.
13. A device driver is a program which controls a particular type of device that is attached to your computer. It allows high level programs to interact with a hardware device.
14. A driver is a program that extends the kernel's functionality. There are many different drivers in the kernel which provide support for hardware devices, file system types, binary executable formats, network protocols, etc.
15. Internal drivers are a part of the kernel memory and thus also a part of the kernel binary. External drivers are not a part of the kernel memory and are loaded into the user memory when required.

2.11 SUMMARY

- Computers have an input-output subsystem, referred to as I/O subsystem, which provides an efficient mode of communication between the central system and the outside world.
- Programs and data must be entered into the computer memory for processing, and results obtained from computations must be displayed or recorded for the user's benefit.

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- Input devices are used to transfer user data and instructions to the computer.
- Keyboard devices allow input into the computer system by pressing a set of keys mounted on a board, connected to the computer system.
- Keyboard devices are typically classified as general-purpose keyboards and special-purpose keyboards.
- Another popular key arrangement, called Dvorak system, was designed for easy learning and use. It was designed with the most common consonants in one part and all the vowels on the other part of the middle row of the keyboard.
- The keyboard facilitates input of data in text form only. While working with display based packages, we usually point to a display area and select an option from the screen (fundamentals of GUI applications).
- A mouse is a small input device used to move the cursor on a computer screen to give instructions to the computer and to run programs and applications. It can be used to select menu commands, move icons, size windows, start programs, close windows, etc.
- A touch screen is probably one of the simplest and most intuitive of all input devices. It uses optical sensors in or near the computer screen that can detect the touch of a finger on the screen.
- A touch pad is a touch sensitive input device which takes user input to control the onscreen pointer and perform other functions like that of a mouse.
- Touch pads are pressure and touch sensitive. They use finger drag and tapping combinations to perform multiple control operations.
- The light pen is a small input device used to select and display objects on a screen. It functions with a light sensor and has a lens on the tip of a pen-shaped device.
- The trackball is a pointing device that is much like an inverted mouse. It consists of a ball inset in a small external box or adjacent to, and in the same unit, as the keyboard of some portable computers.
- The joystick is a vertical stick that moves the graphic cursor in the direction the stick is moved. It consists of a spherical ball, which moves within a socket and has a stick mounted on it.
- Scanning devices are input devices used for direct data entry from the source document into the computer system.
- Hand-held scanners are used where the information to be scanned or the volume of documents to be scanned is exceptionally low.

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- Magnetic ink character recognition is like an optical mark recognition device and is used only in the banking industry.
- MICR readers are used to read and sort cheques and deposits. An MICR reader-sorter reads the data on the cheques and sorts the cheques for distribution to other banks and customers or for further processing.
- Alphanumeric data is represented using adjacent vertical lines called bar codes.
- Card readers are devices that also allow direct data input into a computer system.
- Electronic cards are plastic cards with data encoded on them and meant for a specific application.
- Data stored on magnetic strips cannot be read with the naked eye, a useful way to maintain confidential data.
- Smart cards, going a stage further, have a built-in microprocessor chip where data can be permanently stored.
- An output device is an electromechanical device that accepts data from the computer and translates it into a form that can be understood by the outside world.
- It is almost impossible to even think of using a computer system without a display device. A display device is the most essential peripheral of a computer system.
- The CRT consist of an electron gun with an electron beam controlled with electromagnetic fields and a phosphate-coated glass display screen structured into a grid of small dots known as pixels.
- A multimedia projector is an output device which is used to project information from the computer onto a large screen so that it can be viewed by a large group of people.
- LCD flat screens connected to the computer systems for projecting the LCD image using an overhead multimedia projector are widely used today.
- Printers can be classified as impact or non-impact printers, based on the technology they use for producing output.
- Dot matrix printers are the most widely used impact printers in personal computing.
- Inkjet printers are based on the use of a series of nozzles for propelling droplets of printing ink directly on almost any size of paper.

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- Laser printers work on the same printing technology as photocopiers, using static electricity and heat to print with a high quality powder substance known as toner.
- Plotters are used to make line illustrations on paper. They can produce charts, drawings, graphics, maps, and so on.
- Display processor is interpreter or part of specific hardware that converts display processor code into the form of images or pictures.
- Graphics capabilities for both two-dimensional and three-dimensional applications are now common in general-purpose computer applications, including many handheld tools like calculators.
- Graphics users can use a wide variety of interactive input devices and graphics software packages with personal computers.
- A cathode-ray tube consists of three basic parts: the glass wrapper, the phosphor viewing surface, and the electron gun assembly.
- A cathode-ray tube, used in a colour computer monitor or colour television, has a few additional parts.
- The most common type of graphics monitor, the raster scan, is based on television technology and uses a CRT.
- A liquid crystal display can be made with either a passive or an active matrix display grid.
- The active matrix LCD is also called a Thin Film Transistor (TFT) display.
- A major disadvantage of DVST in interactive computer graphics is its inability to selectively erase parts of an image from the screen.
- The contour and color of the image of a cat can morph into that of the image of a tiger through simple shape and color interpolation.
- Morphing effect can not only be applied in transition between still images but often between moving images as well.
- Angular type creates a sequence that preserves apparent corners and straight lines in the intermediate shapes. Angular is appropriate only for blending shapes with sharp corners and straight lines.
- A device driver is a program which controls a particular type of device that is attached to your computer. It allows high level programs to interact with a hardware device.
- Angular type creates a sequence that preserves apparent corners and straight lines in the intermediate shapes. Angular is appropriate only for blending shapes with sharp corners and straight lines.

NOTES

- Speech recognition, often known as speech-to-text, is the capacity of a machine or programme to recognise and transform spoken words into legible text.
- Speech recognition technology is a form of technology that enables a computer to recognize and translate the words spoken into a microphone into written text.
- Speech recognition is works using acoustic and linguistic modelling techniques.
- Connected word systems are similar to isolated words but allows separate utterances to be 'run-together' with a minimal pause between them.
- Continuous speech recognizers allow users to speak almost naturally, while the computer determines the content.
- The most frequent applications of speech recognition within the enterprise include the use of speech recognition in mobile devices.
- Speech recognition has several drawbacks, including the failure to catch words in some cases due to variances in pronunciation, the absence of support for some languages, and the inability to sort through background noise.
- Handwriting recognition refers to a computer or mobile device's capacity to recognize handwriting as text.
- The most widely used technique for handwriting recognition is Optical Character Recognition (OCR). This is achieved by scanning and converting a handwritten document into a plain text document.
- Speech is the oldest ways for humans to exchange information. Attempts to develop vocally interactive computers to realize voice/speech synthesis have been made over the years.
- One of the most appealing applications is unified messaging. It combines voicemail and email into a single unified mailbox that can be accessed via regular email programmes, the Web, and the phone.

2.12 KEY WORDS

- **Display file memory:** Display file memory is typically used for generation of the image or picture.
- **Display controller:** Display controller handles interrupt, maintains timings, and is typically used for interpretation of instruction(s).

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- **Display generator:** Display generator is used for the generation of character. It is also used to generate the curves.
- **Display console:** Display contains CRT, Light Pen, Keyboard, and the deflection system.
- **Sequential mode:** This is the default JPEG mode we have discussed so far. Each gray level image or color image component is encoded in a single left-to-right, top-to-bottom scan.
- **Progressive mode:** The key difference with the sequential mode is that each image component is encoded in multiple scans rather than in a single scan.
- **Histograms:** A histogram graphs the number of pixels at each brightness level in an image.
- **Input devices:** They are used to transfer user data and instructions to the computer.
- **Keyboard devices:** They allow input into the computer system by pressing a set of keys mounted on a board, connected to the computer system.
- **Special function keys:** Special functions are assigned to each of these keys.
- **Speech recognition technology:** It is a form of technology that enables a computer to recognize and translate the words spoken into a microphone into written text.
- **Handwriting recognition:** It refers to a computer or mobile device's capacity to recognize handwriting as text.

2.13 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are the general purpose keyboards?
2. State the significance of joystick.
3. What are hand-held contact scanners?
4. Define the term flatbed plotters.
5. What are the frame buffers?
6. Differentiate between sequential mode and progressive mode.

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7. How is image processing done?
8. Define the term dithering.
9. Why is halftoning important?
10. What is error diffusion?
11. Write a short note on video display devices.
12. What do you understand by handwriting recognition?
13. Write down applications of handwriting recognition.
14. What do you understand by speech generation?
15. Why speech generation is important?

Long-Answer Questions

1. Discuss briefly about input and output devices giving examples.
2. Elaborate on the types of printers giving example of each.
3. Describe the concept of image display and explain the different types of display features.
4. What are JPEG modes. Explain few commonly used JPEG modes giving suitable examples.
5. Elaborate on 3D images and operations giving suitable examples.
6. Discuss about image editing and modeling software giving appropriate examples.
7. Explain various techniques of handwriting recognition giving suitable examples.
8. Explain various techniques of handwriting recognition giving appropriate examples.

2.14 FURTHER READINGS

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UNIT 3 COLOR AND CONTENT

NOTES

Structure

3.0 Introduction
3.1 Objectives
3.2 Color Uses and Limitations
3.3 Content Uses and Limitations
3.4 Answers to Check Your Progress Questions
3.5 Summary
3.6 Key Words
3.7 Self Assessment Questions and Exercises
3.8 Further Readings

3.0 INTRODUCTION

Color or colour is the characteristic of visual perception described through color categories, with names, such as red, orange, yellow, green, blue, or purple. This perception of color derives from the stimulation of photoreceptor cells by electromagnetic radiation. Color categories and physical specifications of color are associated with objects through the wavelengths of the light that is reflected from them and their intensities. This reflection is governed by the object's physical properties, such as light absorption, emission spectra, etc.

The science of color is sometimes called chromatics, colorimetry, or simply color science. It includes the study of the perception of color by the human eye and brain, the origin of color in materials, color theory in art, and the physics of electromagnetic radiation in the visible range. The color of an object depends on both the physics of the object in its environment and the characteristics of the perceiving eye and brain. Physically, objects can be said to have the color of the light leaving their surfaces, which normally depends on the spectrum of the incident illumination and the reflectance properties of the surface, as well as potentially on the angles of illumination and viewing. Some objects not only reflect light, but also transmit light or emit light themselves, which also contributes to the color.

In publishing, art, and communication, content is the information and experiences that are directed toward an end-user or audience. Content is something that is to be expressed through some medium, as speech, writing or any of various arts. Content can be delivered via many different media including the Internet, cinema, television, radio, smartphones, audio CDs, books, e-books, magazines, and live events, such as speeches, conferences and stage performances.

In this unit, you will study about the significance of colors, importance of colors, the right use of colors, choosing right colors, content and its various uses.

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3.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of colors and its importance
- Discuss about the importance of colors
- Know about the color uses
- Learn about the process of choosing right colors
- Discuss about content and its various uses

3.2 COLOR USES AND LIMITATIONS

Color concerns are particularly important in Human Computer Interaction (HCI) and are essential in affective computing. Affective computing is an interdisciplinary branch of study that tries to bring together topics concerning emotions and computers. As a result, an updated study of the importance of light and color in affective computing appears to be necessary.

Right color to the right content improves the human interaction with the computer anonymously.

Importance of Colors

Colors can communicate in ways that are just as strong as language. They have the potential to represent your company's personality. They can attract users, and they can better communicate your message.

Color schemes have a significant impact on HCI when used correctly and can greatly improve user interfaces. At the same time when used incorrectly they can decrease the functionality of the interface. Simplicity, consistency and clarity are all important considerations when designing color interfaces. To begin, you will want to keep the color scheme simple.

The Color Wheel

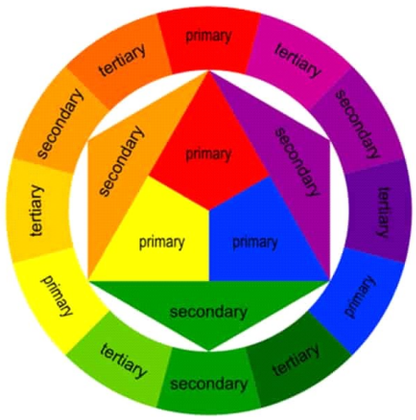

Fig. 3.1 Color Wheel

Three primary colors (RED, YELLOW AND BLUE), three secondary colors (ORANGE, GREEN AND VIOLET) and six tertiary colors make up the fundamental color wheel (RED-ORANGE, YELLOW-ORANGE, YELLOW-GREEN, BLUE-GREEN, BLUE-VIOLET AND RED-VIOLET).

NOTES

Color Uses

Simplicity can be achieved by using the four primary colors, which are red, green, yellow and blue. Another important factor to consider when designing an interface is consistency. Colors may be assigned to specific types of concepts or to aid in the classification of data. This method aids users in retaining more data in their short-term memory. They also help is provided clarity and the use of color in a concise manner. Color can be used as a grouping method or to draw attention to certain aspects of the system. Some common issues with color use are too many colors, complementary colors placed too close together, excessive saturation, inadequate contrast and inadequate attention to color impairment.

Choosing Colors

It is important to choose the color conservatively because the more color we use, user look for the more information. It also becomes difficult to understand the content. You want to choose the appropriate one at the appropriate time and in the appropriate pattern. They must be targeted at the right users and you should choose them to achieve the right objectives. There are certain emotions associated with the colors. Colors really play an important role in brand recognition and getting the attention of the customers for a specific service or product. Customers instantly make a judgment about any service or product thinking about the color used to represent the service and the product. It is directly connected with human emotions and it can create a positive or negative impact on users.

1. Choose Your Primary (Dominant) and Secondary Color

The primary color or the dominant color is the base color of your UI or User Interface. Generally, designers choose the primary color from the logo of the Website. Dominant color represents the brand of your Website and it brings out certain emotion when a user visits on your Website or think about your services and product.

- ***Warm Colors***

The red refers to what we call warm colors. Red, orange and yellow are the colors which brings the warmth and comfort. These colors might also reflect the passion, anger and hostility.

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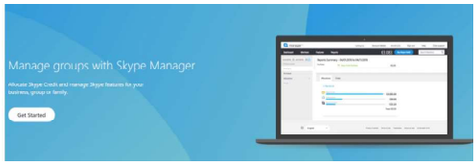
- ***Cold Colors***

The cold colors are blue and indigo. Sweetness, quietness, trust, confidence, and contemplation are associated with these colors. Many organizations use blue color to increase trust towards the company.



- ***Color of Joy and Happiness***

Yellow often symbolizes joy, happiness, and sunlight. That is very appropriate when speaking about social media networks. For example, the Snapchat uses color in logo.

- ***Color for Calm Feelings***

Green brings calm feelings of renewal. These emotions fit well with such brand as Tropicana that uses green as main logo color. Green is a color that symbolises new beginnings, abundance and nature. It has a soothing effect as well as a practical meaning.

- ***Color of Mystery and Tragedy***

Black signifies mystery, but it is also commonly associated with death and tragedy. Other times, it might mean modern or traditional.

- ***Color of Purity***

White usually means wholesomeness, clarity, purity and innocence.

NOTES

- ***Color for Wealth and Royalty***

Purple is a color associated with wealth and royalty, and it is one of the colors used by the Asprey jewellery brand in its color palette.

- ***Color for Happiness and Vitality***

Orange is an energetic color that speaks of happiness and vitality. It creates excitement and is perfect for calls to action.

2. Accent Colors

Accent colors are generally used to highlight the UI elements, such as progress bar, buttons, quotes, subtitles, links, headlines, sliders, switches and some important information.

Choosing an accent color is not an easy task, it should blend well together with other colors used on the Website. You should have a good understanding of color theory. Accent colors have generally more saturation and brightness and that encourages user interaction.

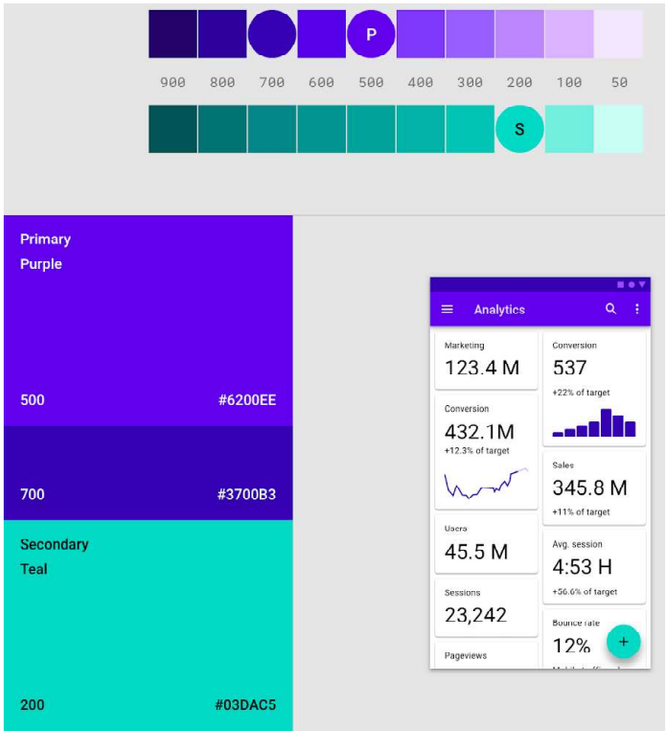


Fig 3.2 *Color Theory*

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3. Background or Neutral Colors

Neutral colors or the background colors are generally used for the text or the background of the Website. A user should feel comfortable when he or she sees the background color of the Website. Imagine you enter a room and you notice the color of the wall. The color of the wall should not be overwhelming and it should be soothing enough that you can spend hours in the room and it should give you the feeling of relaxation. Choosing this color is also a tricky game because if you chose the wrong color then it can make the reverse impact and the room may also give the feeling of boredom or dullness. Choosing the background color depends on what you want your visitors to focus on or the purpose of your Website.

4. Semantic Colors

Semantic colors are generally used to deliver information, such as warning, danger, success and error. These colors are generally reserved colors that UI designers use in the Websites. Red is used for errors, green for success, yellow for warning and blue for informational messages.

- ***Colors and Emotions***

Color along with other important visual elements like shape, size and others, is an important part of computer interfaces. It plays an important role as an essential component of affective communication between users and computers. Color has a big impact on our emotions and feelings, and it has been studied a lot in terms of color/mood associations, color meaning, color preference, and color perception by different demographic groups and psychologically healthy and unhealthy people.

Following table describes the colors and their impacts on emotions.

Table 3.1 *Color in Visual Affect Recognition*

Emotion(s)	Color Description Model and Color Sample
Semantic scales warm/cool, heavy/light, active/passive, and like/dislike	Two-color model, CIELAB; 190 color pairs
12 emotion variables (word pairs)	Munsell color system, SCOTDIC PLUS 2000 system; 214 color samples
Semantic word pairs "bright-dark" (activity factor), "like-dislike" (evaluation factor) and "strong-weak" (potency factor)	2 datasets with different stimuli and scales; 27 color pairs, composed of eight colors (red, blue, green, yellow, orange, cyan, magenta, and violet); luminances and CIE xy color coordinates
Attributes associated with emotional responses	Brightness level (light, medium, dark) and nine hues (red; orange; yellow/orange; yellow; green; blue/green; blue; purple; and white/gray/black)
Heart rate variability (HRV)	Blue, red and white colored fluorescent lights
Color emotions described in 12 opponent word pairs	SCOTDIC PLUS 2000 system, Munsell color system; 218 color samples
12 emotion variables (word pairs)	Working environments with no color at all; with neutral colors; with not very vivid color; very colorful and vivid
Three emotion factors: activity, weight, and heat	RGB space; 567 samples
Color emotion based on the analysis of color preference questionnaires	Self-created color space, where value and chroma are controlled, and hue parameter are changed with a constant physical difference in hue of 20 grades, with addition of black and white, totally 23 home page color schemes

3.3 CONTENT USES AND LIMITATIONS

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In publishing, art, and communication, content is the information and experiences that are directed toward an end-user or audience. Content is something that is to be expressed through some medium, as speech, writing or any of various arts. Content can be delivered via many different media including the Internet, cinema, television, radio, smartphones, audio CDs, books, e-books, magazines and live events, such as speeches, conferences and stage performances.

1. Page Title

A page title, also known as a title tag, is a short description of a Web page and appears at the top of a browser window and Search Engine Results Pages (SERPs). It is an important element of an optimized Search Engine Optimization (SEO) page. A page title should include a page's keyword in the title tag.

It looks like `<title>This Is A Title</title>`

The title of a page will often be on the page in the form of an H1 tag. Additionally, the title can often be found in the Head section of the page's code. A good page title accurately describes what a visitor will find on that page as well as opening enough curiosity that a person searching for that content would want to click on it and read more. From an SEO perspective, page titles are important for two reasons. First, it is a clear indication telling Google what your page is about. Secondly, the page title is shown as a clickable link in the SERP or (Search Engine Results Page)

Features of a page title:

- It should contain many keywords at possible.
- It should possess meaningful keywords.
- It should make sense when viewed completely out of context.
- It should be different from other page titles.
- It should be written in mixed case using the headline.
- It should not highlight keywords.

2. Headings

A heading is a short phrase describing what the succeeding section is all about. You can think of it as the title of that section. Short documents usually do not require the use of headings. For these and other complex readings, however, headings are important because they help readers identify the main points of each section in the paper. Headings should be used to rank or order your content. Simply bolding or underlining topic items can seem the obvious way to do this, yet it does not actually adequately order that content. Using headings is easy in OU Campus. They are all listed in your editor toolbar. The default setting is paragraph,

which is what you will use for your regular, paragraph text. APA or American Psychological Association has specific formatting guidelines for each heading level that need to be followed consistently.

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Table 3.2 *Heading Level Format*

APA Headings	
Level	**Format**
1	**Centered, Boldface, Uppercase and Lowercase Headings**
2	**Flush left, Boldface, Uppercase and Lowercase Heading**
3	**Indented, boldface, lowercase paragraph heading ending with a period.**
4	***Indented, boldface, italicized, lowercase paragraph heading ending with a period.***
5	*Indented, italicized, lowercase paragraph heading ending with a period.*

Features of Heading

- **Keep headings concise:** Headings should be one to five words long, like a title. Subheadings, on the other hand, can be a little longer since they expound on the heading.
- Headings and subheadings should supplement the substance of your paper. They should frame your topic, not overwhelm the whole segment.
- Not all paragraphs need a subheading. And only use headings if you have more than one point per heading level.
- Do not type out the page title as a Heading. It is automatically put onto the page for you, and by manually typing it into the editor, it will appear twice on your page.
- Do not abbreviate words in page names.
- Do not skip a header level for styling reasons. A heading or subheading format should never be used to style any other type of content.
- Do not bold or italicize a heading.
- Do not try to be clever or play on words. Some readers, such as non-native speakers of English, may not understand the pun intended.
- Do not use all caps. Doing so may cause some screen readers and assistive technology to read out each individual letter of your words, instead of the full words themselves. Certain parts of your Website may show text in all caps, but that is done automatically for you. You do not need to do it yourself.

3. Text - Messages

Text-based communication is familiar to most people, in that they will have written and received letters. The text-based communication in groupware systems is acting as a speech substitute and, thus, there are some problems adapting between the two media. There are various types of text messages that user can send or receive.

Types of textual communication:

- Discrete
- Linear

- Non-linear
- Spatial

Discrete

Example of directed message is email, where there is no explicit connection between different messages, except in so far as the text of the message refers to a previous one.

Linear

In linear messaging, participant's messages are added in usually temporal order to the end of a single transcript.

Non-Linear

A message become non-linear when messages are linked to one another in a hypertext fashion.

Spatial

Spatial messages are arranged on a two-dimensional surface.

4. Error Messages

Your message, or what you are attempting to express visually about your Website or application, is a vital design aspect. Error prevention makes it difficult to make errors. Good error messages are a careful design that prevents a problem from occurring in the first place. But still, we cannot avoid errors fully, but it is important to handle all the error messages carefully.

Application should help users to recognize, diagnose and recover from errors. Error messages should be expressed in plain language, precisely indicate the problem, and constructively suggest a solution.

Error messages should be handled gracefully and should provide good experience of handling the same. Few things to be considered while handling errors.

• Error Message Should be Specific and Relevant.

Error message should clearly point the exact location of the issue, including where the user should go and what steps they should do to fix it. The error message should include relevant information that allows the user to quickly relate to the provided location and alternative options. If an error message contains ambiguous information, the user will feel perplexed, making it difficult for him to correct the problem. A message should contain useful information as shown below in screenshot:

• Error Messages Need to be Short and Meaningful.

The error message should contain the necessary information. Most of the time user is not willing to read a long story. Be concise and write a short description

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that is meaningful for the user and gives him a clear idea of the problem and how to resolve it. Avoid using redundant words and do not over-communicate the problem.

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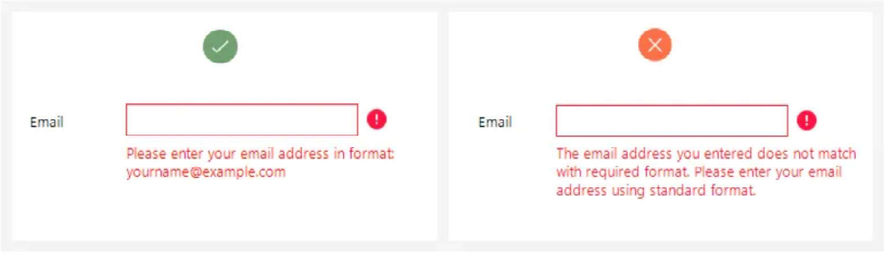
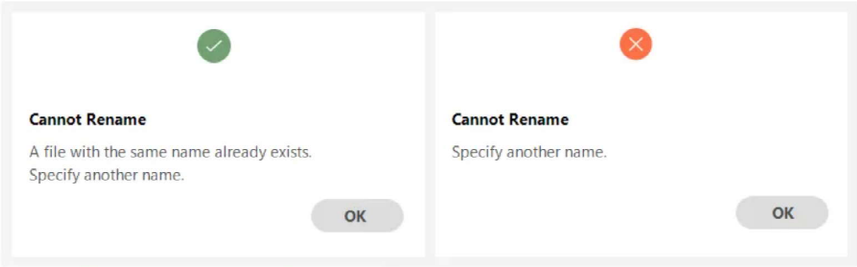


A precise and meaningful indication of the desired behavior.

A long message containing unnecessary details but missing the required information.

- **Give Direction to User.**

A good error message contains three parts: identification of the problem, cause details if available, and a solution if possible. When a user encounters a mistake, they want to solve it as fast as possible. The error message should provide the user with sufficient information to help him out of the incorrect condition.

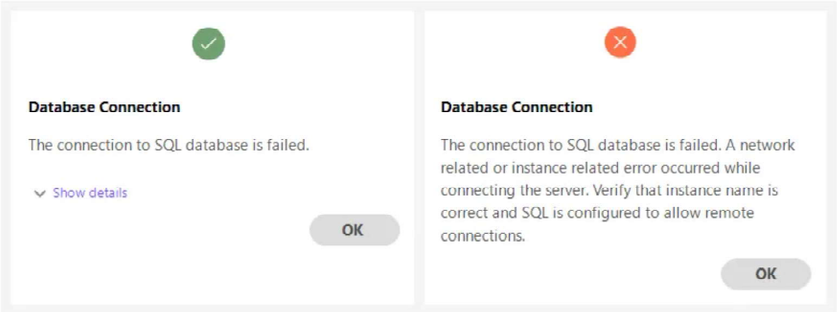


The message contains problem, cause of error and solution.

The cause of error is missing in the message.

- **Use Progressive Disclosure Approach.**

Sometimes it is important for the user to know the detailed information but not always. In such cases it is important to use Show/Hide section. It can be useful for an advanced user that may want to know about technical details.



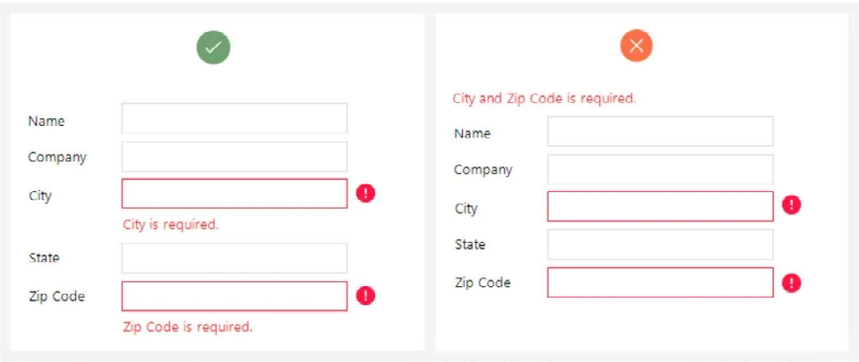
Detailed technical information is hidden and user can open it if he wants to know about it.

Technical details are mentioned in default view of error message.

NOTES

• **Use Proper Placement.**

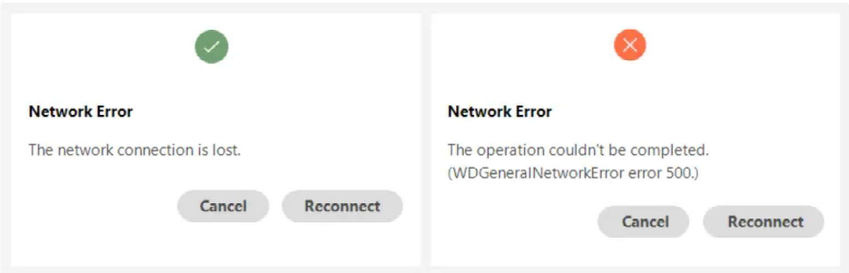
It is important to position an error message closer to the location where it exactly belongs. Users should not have to look around after reading the message to figure out what it is about. For example, when the user is filling the information in a form, it is the best experience to provide validation error along with the controls it relates to.



It is better to display error message along with relevant options. User will take a while to relate the error message with options

• **No Use of Technical Terms.**

Most of the users are not interested in the technical details of the problem that occurred. If a message contains technical terms or jargons, the user gets confused. The technical details should be mentioned in troubleshooting section not as error message. Because troubleshooting section direct the user so that he can resolve the issue quickly.



User is informed about the problem using simple language. User is not concerned with technical detail of error occurred.

• **Appropriate Actions.**

The error messages actions are very essential. Appropriate actions give the user direction on what to do next. Actions are options for resolving the issue. A message can include one or more user actions. Message should be clear and not ambiguous.

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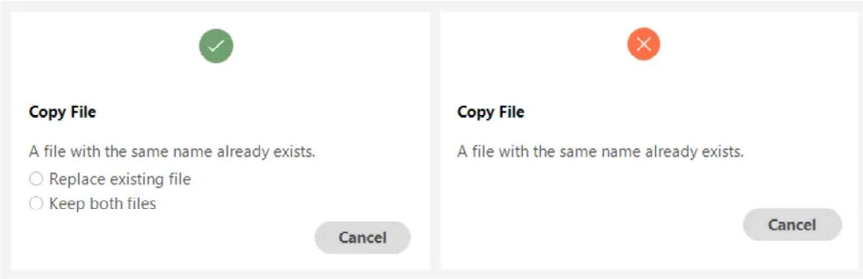

Appropriate actions are given to resolve the problem. The action does not guide the user about solving the problem.

5. Icons

An icon acts as a shortcut to an action the computer performs (e.g., execute a program or task). Icons are the most popular type of graphic used in interface design. Icons are especially useful to communicate ideas and actions to users in a constrained visual space. The problem is ensuring that the user understands the icon's significance. Icons are used as the means to communicate important information, via a symbol or an image. Like illustrations or typography, icons should also match the style and tone of the brand. There are a few characteristics of an icon that collectively form a part of well-designed icons.

Characteristics of Icons

- **Clarity**

Icons should be understandable to the user in a single glance. They should be designed & drawn clearly and relative to the context or object you are trying to represent. The clarity in icons enhances the memorability of the design as the user can recognize from the prior references. For example, the icon of an airplane for putting the phone to a flight mode is easily understandable by the user.

- **Consistency**

The style, the color schemes you chose to design icons should be consistent throughout the interface. It should resonate with the other elements of the interface. The consistency helps in better understandability of the interface, as the user can relate with the previous interactions, he had with the interface. Last, but not least, choose a consistent style across the interface.

- **Scalability**

The icons you design should be scalable for smaller to larger screens. Designers face this issue while designing for larger screens. If not appropriately scaled, when the user views the same Website on a smaller screen, the icons appear pixelated as well as distorted. It ends up providing a bad experience to the user.

- **Color Schemes**

Color schemes you chose for your icons are essential as well. The color palette you choose or the style guide you decide for your icons defines a lot about the brand and the visual appearance of the icons. Every color you choose should have

a meaning attached to it. Correctly chosen colors can set the look and style aside and helps in delivering the correct message.

Check Your Progress

1. Why choosing right color is important?
2. Define the term cold colors.
3. Which color is known as color of mystery and tragedy?
4. State the significance of accent colors.
5. What are neutral colors?
6. What is a page title also known as?
7. Why are the error messages important?
8. Define the term icon.

NOTES

3.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Right color to the right content improves the human interaction with the computer anonymously.
2. The cold colors are blue and indigo. Sweetness, quietness, trust, confidence, and contemplation are associated with these colors. Many organizations use blue color to increase trust towards the company.
3. Black signifies mystery, but it is also commonly associated with death and tragedy. Other times, it might mean modern or traditional.
4. Accent colors are generally used to highlight the UI or User Interface elements, such as progress bar, buttons, quotes, subtitles, links, headlines, sliders, switches and some important information.
5. Neutral colors or the background colors are generally used for the text or the background of the Website. A user should feel comfortable when he/she sees the background color of the Website.
6. A page title, also known as a title tag, is a short description of a Web page and appears at the top of a browser window and in SERPs or Search Engine Results Page. It is an important element of an optimized SEO or Search Engine Optimization page. A page title should include a page's keyword in the title tag.
7. Error messages are important because your message, or what you are attempting to express visually about your Website or application, is a vital design aspect. Error prevention makes it difficult to make errors. Even better than good error messages are a careful design that prevents a problem from occurring in the first place.

8. An icon acts as a shortcut to an action the computer performs e.g., execute a program or task. Icons are the most popular type of graphic used in interface design.

NOTES

3.5 SUMMARY

- Color concerns are particularly important in Human- Computer Interaction (HCI) and are essential in affective computing.
- Affective computing is an interdisciplinary branch of study that tries to bring together topics concerning emotions and computers.
- Right color to the right content improves the human interaction with the computer anonymously.
- Colors can communicate in ways that are just as strong as language. They have the potential to represent your company's personality.
- Color schemes have a significant impact on HCI when used correctly and can greatly improve user interfaces.
- Colors may be assigned to specific types of concepts or to aid in the classification of data.
- It is important to choose the color conservatively because the more color we use, user look for the more information. It also become difficult to understand the content.
- The red refers to what we call warm colors. Red, orange, and yellow are the colors which brings the warmth and comfort. These colors might also reflects the passion, anger and hostility.
- The cold colors are blue and indigo. Sweetness, quietness, trust, confidence, and contemplation are associated with these colors.
- Neutral colors or the background colors are generally used for the text or the background of the Website.
- Semantic colors are generally used to deliver information such as warning, danger, success, and error.
- A page title, also known as a title tag, is a short description of a Web page and appears at the top of a browser window and in SERPs.
- A heading is a short phrase describing what the succeeding section is all about. Short documents usually do not require the use of headings.
- Headings should be used to rank or order your content.
- Headings and subheadings should supplement the substance of your paper, not take the place of your topic sentences. They should frame your topic, not overwhelm the whole segment.

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- Error messages should be handled gracefully and should provide good experience of handling the same. Few things to be considered while handling errors.
- The error message should include relevant information that allows the user to quickly relate to the provided location and alternative options.
- The error messages actions are very essential. Appropriate actions give the user direction on what to do next.
- An icon acts as a shortcut to an action the computer performs e.g., execute a program or task. Icons are the most popular type of graphic used in interface design.
- Icons should be understandable to the user in a single glance. They should be designed and drawn clearly and relative to the context or object you are trying to represent.
- Color schemes you chose for your icons are essential as well. The color palette you choose or the style guide you decide for your icons defines a lot about the brand and the visual appearance of the icons.

3.6 KEY WORDS

- **Warm colors:** The red refers to what we call warm colors. Red, orange and yellow are the colors which brings the warmth and comfort.
- **Cold colors:** The cold colors are blue and indigo. Sweetness, quietness, trust, confidence, and contemplation are associated with these colors.
- **Neutral colors or the background:** These colors are generally used for the text or the background of the Website.
- **Semantic colors:** They are generally used to deliver information, such as warning, danger, success, and error.
- **Page title:** It is also known as a title tag, is a short description of a Web page and appears at the top of a browser window and in SERPs.
- **Icon:** It acts as a shortcut to an action the computer performs. Icons are the most popular type of graphic used in interface design.

3.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Why are colors important?
2. Differentiate between warm and cold colors.
3. What is the link between colors and emotions?

4. What does the page title look like?
5. State the significance of a heading.
6. What are text messages?

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Long-Answer Questions

1. Discuss the significance of colors and list its important features.
2. Elaborate on color wheel giving suitable examples.
3. Explain the features of heading by giving appropriate examples.
4. What are error messages? Explain its important features.
5. Describe the significance of icons and state its characteristics.

3.8 FURTHER READINGS

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UNIT 4 USER INTERFACE DESIGN PROCESS-I

NOTES

Structure

4.0 Introduction
4.1 Objectives
4.2 User Inteface Model
4.3 Designing an Interface
  4.3.1 Process of Interaction Design
  4.3.2 Techniques for Getting the User's Attention
4.4 Answers to Check Your Progress Questions
4.5 Summary
4.6 Key Words
4.7 Self Assessment Questions and Exercises
4.8 Further Readings

4.0 INTRODUCTION

User interface modeling is a development technique used by computer application programmers. Today's User Interfaces (UIs) are complex software components, which play an essential role in the usability of an application. The development of UIs requires therefore, not only guidelines and best practice reports, but also a development process including the elaboration of visual models and a standardized notation for this visualization. The term user interface modeling is mostly used in an information technology context. A user interface model is a representation of how the end user interact with a computer program or another device and also how the system responds. The modeling task is then to show all the 'directly experienced aspects of a thing or device'.

Modeling user interfaces is a well-established discipline like modeling techniques can describe interaction objects, tasks, and lower-level dialogs in user interfaces. Using models as part of user interface development can help capture user requirements, avoid premature commitment to specific layouts and widgets, and make the relationships between an interface's different parts and their roles explicit.

In this unit, you will study about the user interface model, different aspects of user interface model, design an interface, process of interface design and techniques of getting user attention.

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4.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of user interface model
- Discuss about the different aspects of user interface model
- Know about how to design an interface
- Learn about the process of interface design
- Discuss about the techniques of getting user attention

4.2 USER INTEFACE MODEL

User Interface (UI) modelling is a development technique used by computer application programmers. Today's user interfaces are complex software components, which play an essential role in the usability of an application. The development of UIs requires therefore, not only guidelines and best practice reports, but also a development process including the elaboration of visual models and a standardized notation for this visualization. The term user interface modeling is mostly used in an information technology context. A user interface model is a representation of how the end user interact with a computer program or another device and how the system responds. The modeling task is then to show all the 'directly experienced aspects of a thing or device'.

Modeling user interface is a well-established discipline. For example, modeling techniques can describe interaction objects, tasks and lower-level dialogs in user interfaces. Using models as part of user interface development can help capture user requirements, avoid premature commitment to specific layouts and widgets and make the relationships between an interface's different parts and their roles explicit.

The different aspects of a user interface require different model types. Some of the models that may be considered for UI modeling are:

- Domain model, including data model defines the objects that a user can view, access and manipulate through the user interface.
- Navigation model defines how the objects that a user view could be navigated through the user interface.
- Task model describes the tasks an end user performs and dictates what interaction capabilities must be designed.
- User model represents the different characteristics of end users and the roles they are playing within the organization.

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- Platform model used to model the physical devices that are intended to host the application and how they interact with each other.
- Dialogue model defines how users can interact with the object's presentation as push buttons, commands, etc., with interaction media as voice input, touch screen, etc., and the reactions that the user interface communicates via these objects.
- Presentation model application appearance, representation of the visual, haptic and auditory elements that the user interface offers to its users.
- Application model commands and data the application provides.

Primary methods used in the interface design include prototyping and simulation. Typical human–machine interface design consists of the following stages: interaction specification, interface software specification and prototyping:

- Common practices for interaction specification include user-centered design, persona, activity-oriented design, scenario-based design and resiliency design.
- Common practices for interface software specification include use cases and constrain enforcement by interaction protocols intended to avoid use errors.
- Common practices for prototyping are based on libraries of interface elements like controls, decoration, etc.

4.3 DESIGNING AN INTERFACE

Designing a user interface can appear to be a minor aspect of an application's growth. It is, in truth, perhaps the most crucial aspect of application growth. User interface design is, in fact, included in a much larger field of Human Computer Interaction (HCI). This larger field focuses on all aspects of efficiency and effectiveness as humans utilize technology to perform their business tasks. When designing a user interface, keep in mind that you are creating a product that will be used by others. Designers are always too preoccupied with creating an award-winning, cool product to notice that the product could be a total mystery to end users and unusable.

There are different concepts related to user interface design:

- **User Interface Design**

The design of user interfaces for machines and applications, such as computers, home appliances, mobile devices and other electronic devices, with the aim of optimising the user experience, is known as User Interface (UI) design or user interface engineering. The goal of user interface design is to make the user's interaction as simple and efficient as possible, in terms of accomplishing user goals (user-centered design).

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• **Interaction Design**

Interaction design is described as 'the practise of developing interactive digital objects, environments, systems, and services' in the fields of design, human–computer interaction, and software development. Interaction design, like many other design disciplines, is interested in structure, but its primary emphasis is on actions. What distinguishes interaction design from science or engineering is that it emphasises synthesis and imagining things as they may be rather than concentrating on how things are.

• **User Experience Design**

User Experience Design (UED) is the process of improving the usability, functionality, and enjoyment offered in the interaction between the user and the product to increase user satisfaction. Traditional Human–Computer Interaction (HCI) design is complemented by user experience design, which addresses all aspects of a product or service as viewed by users.

• **User Centered Design**

User Centred Design (UCD) is a collection of processes that pay close attention to the needs, desires and shortcomings of end users of a product, service, or process at any point of the design process.

4.3.1 Process of Interaction Design

Interaction design involves four basic activities:

1. Identifying needs and establishing specifications.
2. Developing alternative designs that meet those specifications.
3. Building interactive versions of the designs so that they can be communicated and assessed.
4. Evaluating what is being built throughout the process.

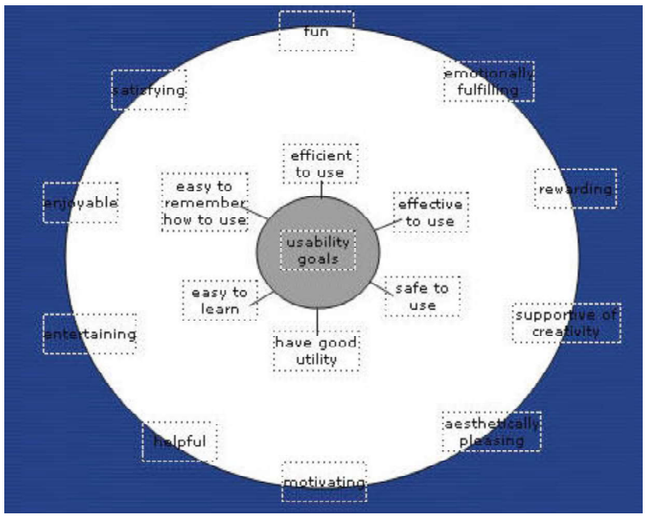

Fig. 4.1 *Three Characteristics of the Interaction Design Process*

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The three characteristics of the interaction design process are:

Users should be involved throughout the development of the project.

Specific usability and user experience goals should be identified, documented and agreed upon at the beginning.

- The design process should be usable. The application should feel familiar, and it should be easy to use.
- The application should be useful. A business product or service needs to be useful.
- The design of the application should be desirable, sleek and to the point. The aesthetics of the system should be attractive and easy to translate.
- Users should be able to quickly find the information they are looking for. Information needs to be findable and simple to navigate. A user should never have to hunt for your product or information.
- The application should support enlarged text without breaking the framework. An application should be accessible to those with disabilities.
- The application should exhibit trustworthy security and company details. The application should be transparent, secure and honest.
- The application should be valuable for the end-user. If all 6 criteria are met, the end-user will find value and trust in the application.

1. Iteration through the four activities (above) is inevitable. Interaction design is an iterative process, involving:
   - Cycling through various design processes and different levels of detail.
   - Thinking through a design problem.
   - Understanding users needs.
   - Coming up with possible models.
   - Prototyping models.
   - Evaluating them
   - Thinking about design implications.
   - Making changes.

4.3.2 Techniques for Getting the User's Attention

In user interfaces, several methods for grabbing the user's attention are commonly used. These techniques are summarized as follows:

1. Animation

The user's attention is quickly drawn to items flashing on the screen. This method can be upsetting and intrusive. Animation is often used to express the GUI's internal state, such as work in progress or general operation.

NOTES

Animation that confuses the user *Wisely used animation*

2. Colour

This technique, like animation, should be used with caution. The use of too many colours can lead to a muddled user interface. On the projector, there are so many colours. Colors on the projector should be used wisely.

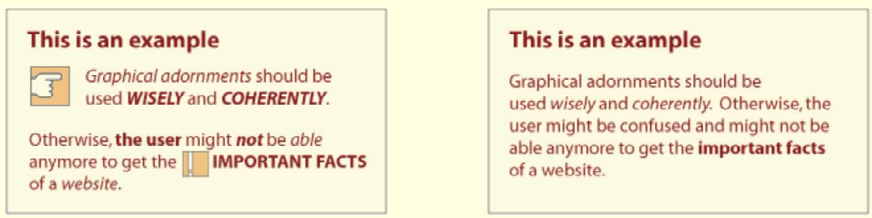
Too many colours on the screen *Wisely used colours on the screen*

3. Sound

When used correctly, technique, like everything else, can be extremely successful. When working with disabled people, sound signals may be a useful form of feedback.

4. Graphic Adornments

Bold fonts, special graphics, and so on are examples of graphics. These graphic conventions can be successful without being distracted when used carefully and consistently.



Graphical adornments are not wisely used *Wisely used graphical adornments*

Check Your Progress

1. What is a modeling user interface?
2. Define the term domain model.
3. State the significance of application model.
4. Define the term User Centred Design (UCD).

NOTES

4.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Modeling user interfaces is a well-established discipline. For example, modeling techniques can describe interaction objects, tasks, and lower-level dialogs in user interfaces.
2. Domain model, including data model defines the objects that a user can view, access, and manipulate through the user interface.
3. Application model commands and data the application provides.
4. User Centred Design (UCD) is a collection of processes that pay close attention to the needs, desires, and shortcomings of end users of a product, service, or process at any point of the design process.

4.5 SUMMARY

- User interface modelling is a development technique used by computer application programmers.
- The term user interface modeling is mostly used in an information technology context. A user interface model is a representation of how the end user interact with a computer program or another device and how the system responds.
- Modeling user interfaces is a well-established discipline.
- Using models as part of user interface development can help capture user requirements, avoid premature commitment to specific layouts and widgets, and make the relationships between an interface's different parts and their roles explicit.
- Domain model, including data model defines the objects that a user can view, access, and manipulate through the user interface.
- Navigation model defines how the objects that a user view could be navigated through the user interface.
- Task model describes the tasks an end user performs and dictates what interaction capabilities must be designed.
- User model represents the different characteristics of end users and the roles they are playing within the organization.
- Platform model used to model the physical devices that are intended to host the application and how they interact with each other.

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- Dialogue model defines how users can interact with the object's presentation as push buttons, commands, etc., with interaction media as voice input, touch screen, etc., and the reactions that the user interface communicates via these objects.
- Primary methods used in the interface design include prototyping and simulation.
- The design of user interfaces for machines and applications, such as computers, home appliances, mobile devices, and other electronic devices, with the aim of optimising the user experience, is known as User Interface design (UI) or user interface engineering.
- Interaction design is described as 'the practise of developing interactive digital objects, environments, systems, and services' in the fields of design, human–computer interaction, and software development.
- User Experience Design (UXD, UED, or XD) is the process of improving the usability, functionality, and enjoyment offered in the interaction between the user and the product to increase user satisfaction.
- User Centred Design (UCD) is a collection of processes that pay close attention to the needs, desires, and shortcomings of end users of a product, service, or process at any point of the design process.

4.6 KEY WORDS

- **Domain model:** It defines the objects that a user can view, access, and manipulate through the user interface.
- **Navigation model:** It defines how the objects that a user view could be navigated through the user interface.
- **Task model:** It describes the tasks an end user performs and dictates what interaction capabilities must be designed.
- **User model:** It represents the different characteristics of end users and the roles they are playing within the organization.
- **Platform model:** It is used to model the physical devices that are intended to host the application and how they interact with each other.
- **Dialogue model:** It defines how users can interact with the object's presentation as push buttons, commands.

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- **Interaction design:** It is described as 'the practise of developing interactive digital objects, environments, systems, and services' in the fields of design, human–computer interaction, and software development.
- **User Centred Design (UCD):** It is a collection of processes that pay close attention to the needs, desires, and shortcomings of end users of a product, service, or process at any point of the design process.

4.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Why is interface design referred to as dialog design?
2. Why are the three important principles emphasized by user-centered design?
3. Why are the three metaphors used to describe human-computer interaction?
4. List some obstacles for UI design.
5. What are the common pitfalls in the design process?

Long-Answer Questions

1. Describe the user interface model with the help of suitable examples.
2. List the models that may be considered for UI modeling giving appropriate examples.
3. How can we design an interface? Explain by giving examples.
4. What is a process interaction design? Elaborate on its characteristics.

4.8 FURTHER READINGS

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BLOCK - II
USER INTERFACE DESIGN AND GRAPHICAL USER INTERFACE

UNIT 5 USER INTERFACE DESIGN PROCESS-II

Structure

5.0 Introduction
5.1 Objectives
5.2 Human Interaction with Computers
  5.2.1 The Process of Design
  5.2.2 Prototyping
5.3 Human Interaction Speeds
5.4 Human Characteristics in Design
5.5 Human Consideration in Design
5.6 Answers to Check Your Progress Questions
5.7 Summary
5.8 Key Words
5.9 Self Assessment Questions and Exercises
5.10 Further Readings

5.0 INTRODUCTION

The user interface or human–machine interface is the part of the machine that handles the human–machine interaction. In the context of computing, the term typically extends as well to the software dedicated to control the physical elements used for human computer interaction. User Interface (UI) design focuses on anticipating what users might need to do and ensuring that the interface has elements that are easy to access, understand, and use to facilitate those actions. UI brings together concepts from interaction design, visual design, and information architecture.

Several researchers have investigated the speed at which people can perform using different communication methods. When choosing between various input and output technologies, designers must frequently consider the speed at which users normally operate. People with little practice can read at 400 words per minute, while those with even less than one hour of practice can easily read at speeds of 600 to 800 words per minute or faster. When people are proofreading (scanning) text on paper they do so at about 200 words per minute. The human factor consideration here starts in design and impact how a person interacts without error with the device.

In this unit, you will study how users interact with computers, types of user interface, process of UI design, human interaction speed, human consideration in design.

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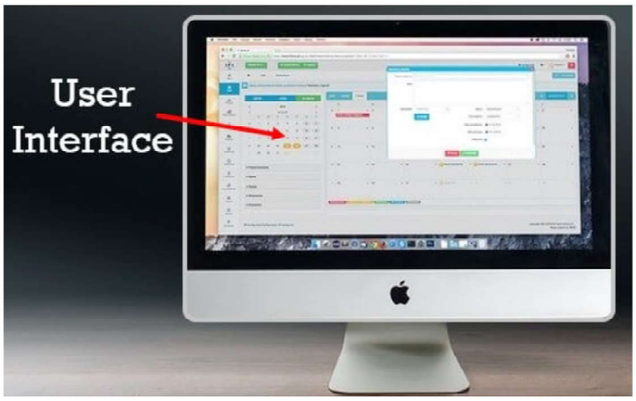
5.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance user interaction with computers
- Discuss about the types of user interface
- Know about the process of UI design
- Learn about the human interaction speed
- Discuss about the human characteristics in UI design
- Learn about human consideration in UI design

5.2 HUMAN INTERACTION WITH COMPUTERS

The process of designing user interfaces in software or computerized devices with an emphasis on appearance or style is known as User Interface (UI) design. Designers strive to build user interfaces that are easy to use and enjoyable to use. UI architecture includes both graphical and non-graphical user interfaces, such as voice-controlled interfaces.



The user interface can be categorized into three types. They are as follows:

1. Command Line Interface (CLI)
2. Menu Based Interface (MBI)
3. Graphical User Interface (GUI)

Command Line Interface (CLI)

In early days, the command line interface was the only way to communicate with the machine. The user must communicate with the machine using textual instructions,

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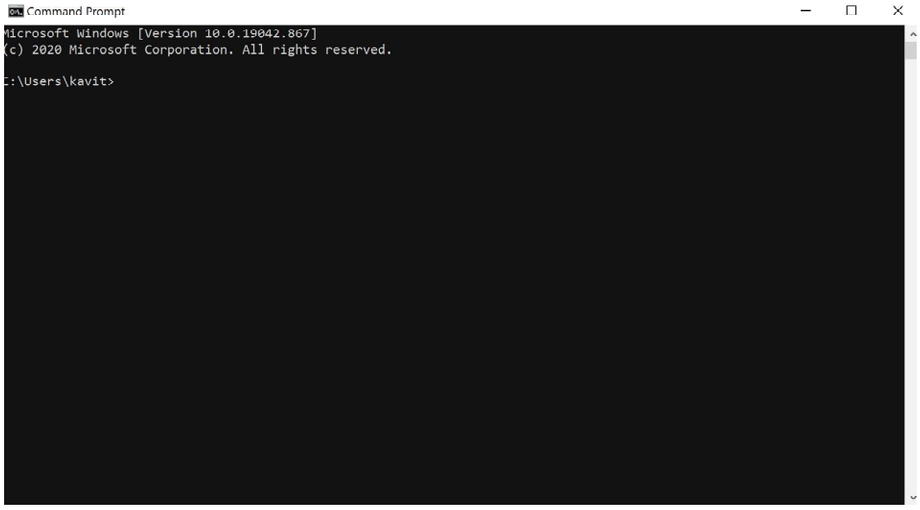
or commands, while using the command-line interface. For instance, if a file needs to be removed from the system. This will be the command:



Disk Operating System (DOS) and Unix operating system are the examples of character user interface, so the operating systems use command line interface. But this kind of user interface is **not user-friendly** as it is hard to learn such commands.

Menu Based Interface (MBI)

It is somewhat easy than the command line interface as users interacting with menu-based interface 'do not have to learn the command name', nor it had to put efforts in writing the commands. As here, the user does not have to type the commands, the syntax error is automatically avoided.

An extremely popular example of a menu based interface is ATM. A user uses menu buttons to select the options from the menu.

Graphical User Interface (GUI)

The user interface of a computer has undergone a to various changes over time. Since today's computers come with a high-resolution screen and pointing devices (mouse). The current computer interface has windows, scroll bars, text boxes, buttons, icons, and menus, and we use a mouse to select and point them. In contrast to the command-line interface, graphical user interfaces are simple to understand. The Interface allows the user to interact with the device through several windows at the same time, and the user can even switch between them.

The actions in a GUI are usually performed through direct manipulation of the graphical elements. Beyond computers, GUIs are used in many handheld mobile devices, such as MP3 players, portable media players, gaming devices, smartphones and smaller household, office, and industrial controls. The term GUI tends not to be applied to other lower-display resolution types of interfaces, such as video games (where Head-Up Display (HUD) is preferred),

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or not including flat screens, like volumetric displays because the term is restricted to the scope of two-dimensional display screens able to describe generic information, in the tradition of the computer science research at the Xerox Palo Alto Research Center. A GUI uses a combination of technologies and devices to provide a platform that users can interact with, for the tasks of gathering and producing information. A series of elements conforming a visual language have evolved to represent information stored in computers. This makes it easier for people with few computer skills to work with and use computer software. The most common combination of such elements in GUIs is the *windows, icons, menus, pointer* paradigm, especially in personal computers.

The WIMP or Windows, Icons, Menus and Pointers style of interaction uses a virtual input device to represent the position of a pointing device's interface, most often a mouse, and presents information organized in windows and represented with icons. Available commands are compiled together in menus, and actions are performed making gestures with the pointing device. A window manager facilitates the interactions between windows, applications, and the windowing system. The windowing system handles hardware devices, such as pointing devices, graphics hardware, and positioning of the pointer. In personal computers, all these elements are modelled through a desktop metaphor to produce a simulation called a desktop environment in which the display represents a desktop, on which documents and folders of documents can be placed. Window managers and other software combine to simulate the desktop environment with varying degrees of realism.

5.2.1 The Process of Design

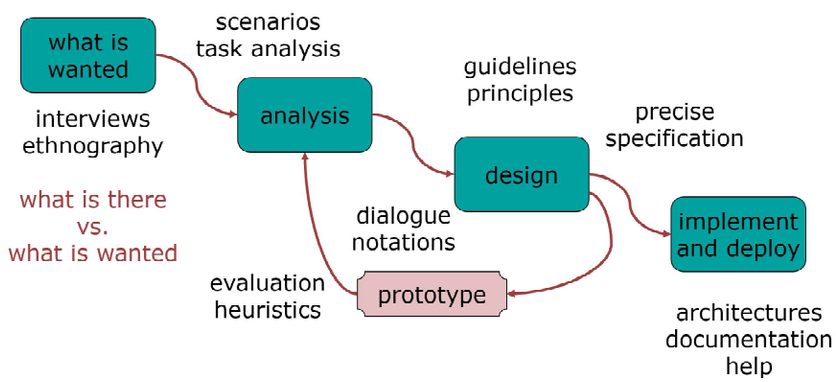

Fig 5.1 *The Process of Design*

Steps involved are in the design process are:

- **Specifications:** In this step we deal with what is already available and what we want to change.

- **Analysis:** The analysis phase helps in understanding the ordering and understanding of design needs.
- **Design:** After analysis, the design step is helpful to know what to design for betterment. In this step it is especially important to decide how to bring the decided design into existence.
- **Iteration and prototyping:** The iteration and prototyping step help in getting it right design by designing a sample and finding what is really needed.
- **Implementation and deployment:** Implementation and then deployment are final phases which bring the design in use for the end users.

5.2.2 Prototyping

Prototypes are one of the most crucial phases in the design process, but for certain designers and project teams, prototyping is still a mystery. A prototype's aim is to test products and product ideas before investing a significant amount of time and money in the final product. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users. Prototyping serves to provide specifications for a real, working system rather than a theoretical one. In some design workflow models, creating a prototype (a process sometimes called materialization is the step between the formalization and the evaluation of an idea.

A prototype can also mean a typical example of something, such as in the use of the derivation 'prototypical'. This is a useful term in identifying objects, behaviours and concepts which are considered with accepted norm and is analogous with terms, such as stereotypes and archetypes.

Prototypes explore different aspects of an intended design:

- A proof-of-principle prototype serves to verify some key functional aspects of the intended design, but usually does not have all the functionality of the final product.
- A working prototype represents all or nearly all the functionality of the final product.
- A visual prototype represents the size and appearance, but not the functionality of the intended design. A form study prototype is a preliminary type of visual prototype in which the geometric features of a design are emphasized with less concern for color, texture, or other aspects of the final appearance.
- A user experience prototype represents enough of the appearance and function of the product that it can be used for user research.
- A functional prototype captures both function and appearance of the intended design, though it may be created with different techniques and even different scale from final design.

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- A paper prototype is a printed or hand-drawn representation of the user interface of a software product. Such prototypes are commonly used for early testing of a software design and can be part of a software walkthrough to confirm design decisions before more costly levels of design effort are expended.

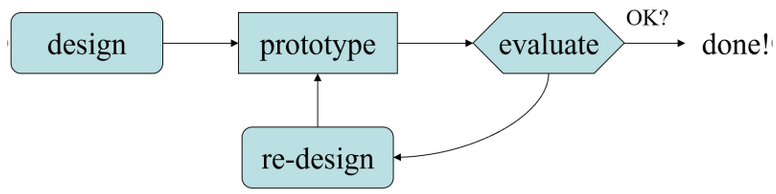

Fig 5.2 *Prototype Design Methodology*

5.3 HUMAN INTERACTION SPEEDS

Several researchers have investigated the speed at which people can perform using different communication methods. When choosing between various input and output technologies, designers must frequently consider the speed at which users normally operate.

1. Reading

The average adult reading speed for English language prose text tends to be about 250 to 300 words per minute. People with less experience can read at 400 words per minute, and those with even less than an hour of experience can read at 600 to 800 words per minute or faster.

2. Listening

People comfortably can hear words that are spoken from 150 to 160 words per minute. There is no reduction of understanding when normal speech is increased to 210 words per minute using compression.

3. Keying

Typists who are the best will type over 150 words per minute. Many occupations necessitate typing at 60-70 words per minute. Real typing rates for people who use machines, on the other hand, are much slower. In one study, basic transcription typing rates averaged only 33 words per minute, while composition typing rates averaged only 19 words per minute.

4. Speaking

Usually, people dictate to machines at a rate of 105 words per minute. When doing transcription, the speaking rate was reduced to an average of 25 words per minute after making the required corrections. When transcribing, new users spoke at an average pace of 14 words per minute, but just 8 words per minute when writing.

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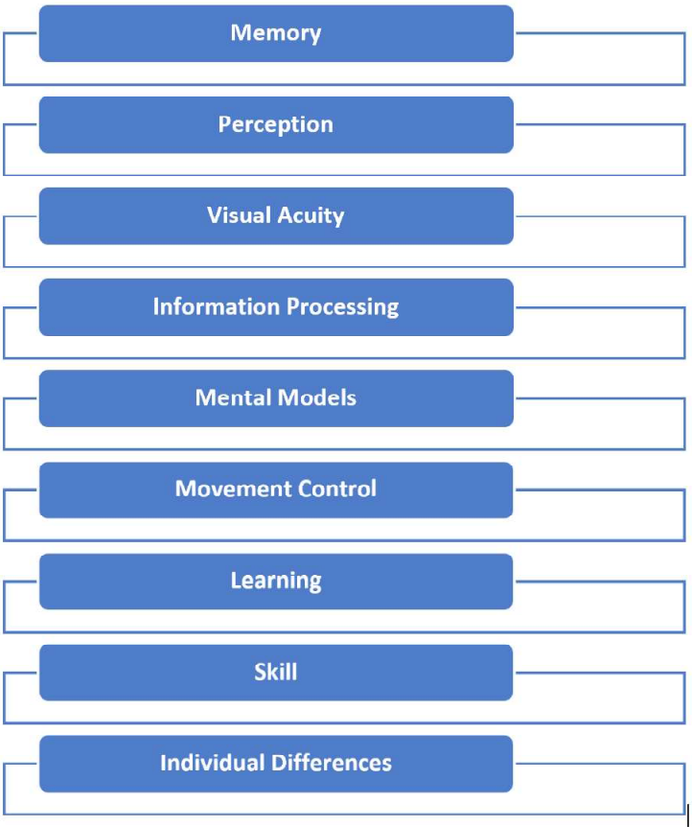
5. Handwriting

On average, people write (handprint) at about 31 words per minute for memorized text, and about 22 words per minute when copying text. It is interesting that the original Remington typewriter was sold with the promise that it would enable users to enter information twice as fast as they could write.

5.4 HUMAN CHARACTERISTICS IN DESIGN

There are many factors who impact the design strongly. Perception, memory, visual acuity, foveal and peripheral vision, sensory storage, information processing, learning, skill, and individual differences are all important in design. Important human characteristics in design that leave impact are:



1. Memory

Memory is viewed as consisting of two components, long-term and short-term (or working) memory.

- Short-term, or working memory.
- Long-term memory

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Short-term, or working memory.

Short-term memory, also known as working memory, absorbs information from the senses or long-term memory, but not at the same time, as the senses are processed separately. Only a small amount of information is processed in short-term memory. The information it stores is thought to last anywhere from 10 to 30 seconds, with the lower amount being the most rational guess. The size and complexity of the information that can be remembered is determined by knowledge, experience, and familiarity.

Long-term memory

Our information is preserved in long-term memory. Learning is the mechanism by which information obtained in short-term memory is transferred to and stored within it. It is a complicated process that will take some time and effort on our part. The learning process is aided by structured, relevant, and familiar knowledge being transferred from short-term memory. Repetition is also helpful to learning. Long-term memory capacity is believed to be limitless, unlike short-term memory, which has distinct limits. The disparity in ability to remember or recall words is a critical memory consideration with major consequences for interface design.

2. Perception

Perception is the physical sensation of our various senses, such as sight, sound, and smell, that allows us to be aware of and understand the elements and objects in our environment. There are many other perceptual characteristics as mentioned below:

- Proximity

When objects are near each other in space, our eyes and minds perceive them as belonging together.

- Similarity

If objects share a similar visual property, such as colour, size, shape, brightness, or orientation, our eyes and minds perceive them as belonging together.

- Matching patterns

We have identical reactions to the same form in various sizes. The alphabet letters, for example, have the same value regardless of their physical dimensions.

- Balance

In our viewing climate, we want it to be secure or balanced. The most visually pleasing and easiest to look at angles are vertical, horizontal, and right angles.

- Expectancies

Expectations affect interpretation as well; we often interpret what we want to see rather than what is there. A perceptual expectancy error occurs when we miss a spelling mistake while proofreading something we have written, we see a word not as it is pronounced, but as we expect to see it spelled.

NOTES

• Context and surroundings

Individual perception is often affected by meaning, climate, and surroundings. For example, depending on the angle of adjacent lines or what other people have said about the size of the lines, two drawn lines of the same length can appear to be the same length or different lengths.

3. Visual Acuity

Visual acuity refers to the eye's ability to resolve fine information. That is the process in which an object becomes more distinct as we shift our gaze toward it and quickly loses differentiation as we move our gaze away from it—that is, as the visual angle from the point of fixation increases.

4. Information Processing

Our senses gather information that is considered significant enough to act on, and this information must be processed in some way. Among us, there are two stages of information processing. Consciousness and working memory are associated with one level, the highest level. It is used for reading and understanding and is limited, slow, and sequential. A lower level of information processing occurs in addition to this higher level, and its capacity limit is uncertain. This lower level processes familiar knowledge quickly and without conscious effort, in parallel with the higher level.

5. Mental Models

A mental model is nothing more than an internal representation of a person's current perception of a topic. Most of the time, a person is unable to explain this mental mode and is unaware that it even exists. To understand something, explain something, decide, do something, or communicate with another person, mental models are gradually created. Mental models often allow an individual to anticipate the actions required to complete tasks, even if the action has been forgotten or not yet experienced.

6. Movement Control

The time it takes to acquire a target is determined by the target's distance and size. This simply means that the larger or closer the target is, the more likely it is to be reached. It will be reached earlier. The following are the consequences for screen design: o Include broad artefacts for essential functions. Make use of the screens pinning behaviour on the sides, top, bottom and corners.

7. Learning

Learning, as previously stated, is the process of encoding information in long-term memory. Learning can be improved if skills learned in one situation can be applied in a similar situation in another. This is done by concept continuity. It offers comprehensive and timely reviews. Human output can be significantly accelerated by a design developed to reduce human learning time. People like to stick with what they are familiar with, and they prefer to jump right in and get started on tasks that are stored in short-term memory.

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8. Skill

The goal of human success is to be able to perform well. To do so, inputs and responses must be connected into a sequence of actions. The nature of skill is the ability to execute acts or movements in the proper time sequence and with sufficient precision. Many simple skills can be combined to form increasingly complex ones since skills are hierarchical in nature. Many simple skills can be combined to form increasingly complex ones since skills are hierarchical in nature. Lower-order skills tend to become routine and can even fade away.

9. Individual Differences

Individual differences complicate design since it must enable people with widely differing characteristics to learn the role or work, or use the Website, satisfactorily and comfortably. There is no average user. A complicating but very advantageous human characteristic is that we all differ—in looks, feelings, motor abilities, intellectual abilities, learning abilities and speed, and so on.

5.5 HUMAN CONSIDERATION IN DESIGN

The human factor consideration here starts in design and impact how a person interacts without error with the device. The kinds of user/task characteristics that must be established are summarized below:

- **The user's knowledge and experience:** The knowledge possessed by a person, and the experiences undergone, shape the design of the interface in many ways.
- **Computer literacy:** Highly technical or experienced, moderate computer experience, or none.
- **System experience:** High, moderate, or low knowledge of a particular system and its methods of interaction.
- **Application experience:** High, moderate, or low knowledge of similar systems.
- **Reading Level**: For textual portions of the interface, the vocabulary and grammatical structure must be at a level that is easily understood by the users.

Mandatory Vs Discretionary Use

Users of the earliest computer systems were mandatory or nondiscretionary. That is, they required the computer to perform a task that, for all practical purposes, could be performed no other way. This newer kind of user is the office executive, manager, or other professional, whose computer use is completely discretionary.

Characteristics of mandatory use can be summarized as follows:

- The computer is used as part of employment.

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- Time and effort in learning to use the computer are willingly invested.
- High motivation is often used to overcome low usability characteristics.
- The user may possess a technical background.
- The job may consist of a single task or function.

Check Your Progress

1. Define the term User Interface (UI) design.
2. Give any two examples of character user interface.
3. What is WIMP style of interaction?
4. State the significance of prototypes.
5. Define the term perception.

5.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The process of designing user interfaces in software or computerized devices with an emphasis on appearance or style is known as User Interface (UI) design.
2. Disk Operating System (DOS) and Unix operating system are the examples of character user interface.
3. The WIMP style of interaction uses a virtual input device to represent the position of a pointing device's interface, most often a mouse, and presents information organized in windows and represented with icons.
4. Prototypes are one of the most crucial phases in the design process, but for certain designers and project teams, prototyping is still a mystery.
5. Perception is the physical sensation of our various senses, such as sight, sound, and smell, that allows us to be aware of and understand the elements and objects in our environment.

5.7 SUMMARY

- The process of designing user interfaces in software or computerized devices with an emphasis on appearance or style is known as User Interface (UI) design.
- UI architecture includes both graphical and non-graphical user interfaces, such as voice-controlled interfaces.

NOTES

- The current computer interface has windows, scroll bars, text boxes, buttons, icons, and menus, and we use a mouse to select and point them.
- The actions in a GUI are usually performed through direct manipulation of the graphical elements.
- A GUI uses a combination of technologies and devices to provide a platform that users can interact with, for the tasks of gathering and producing information.
- A series of elements conforming a visual language have evolved to represent information stored in computers.
- The WIMP style of interaction uses a virtual input device to represent the position of a pointing device's interface, most often a mouse, and presents information organized in windows and represented with icons.
- The windowing system handles hardware devices, such as pointing devices, graphics hardware, and positioning of the pointer.
- Specifications in this step we deal with what is already available and what we want to change.
- The analysis phase helps in understanding the ordering and understanding of design needs.
- After analysis, the design step is helpful to know what to design for betterment. In this step it is especially important to decide how to bring the decided design into existence.
- The iteration and prototyping step help in getting it right design by designing a sample and finding what is really needed!
- Implementation and then deployment are final phases which bring the design in use for the end users.
- Prototypes are one of the most crucial phases in the design process, but for certain designers and project teams, prototyping is still a mystery.
- A prototype's aim is to test products (and product ideas) before investing a significant amount of time and money in the final product.
- A prototype is generally used to evaluate a new design to enhance precision by system analysts and users.
- Prototyping serves to provide specifications for a real, working system rather than a theoretical one.
- A user experience prototype represents enough of the appearance and function of the product that it can be used for user research.
- A functional prototype captures both function and appearance of the intended design, though it may be created with different techniques and even different scale from final design.

- A paper prototype is a printed or hand-drawn representation of the user interface of a software product.
- Short-term memory, also known as working memory, absorbs information from the senses or long-term memory, but not at the same time, as the senses are processed separately.
- Learning is the mechanism by which information obtained in short-term memory is transferred to and stored within it. It is a complicated process that will take some time and effort on our part.
- Long-term memory capacity is believed to be limitless, unlike short-term memory, which has distinct limits.
- Perception is the physical sensation of our various senses, such as sight, sound, and smell, that allows us to be aware of and understand the elements and objects in our environment.
- A perceptual expectancy error occurs when we miss a spelling mistake while proofreading something we have written, we see a word not as it is pronounced, but as we expect to see it spelled.

5.8 KEY WORDS

- **Analysis:** The analysis phase helps in understanding the ordering and understanding of design needs.
- **Design:** After analysis, the design step is helpful to know what to design for betterment. In this step it is especially important to decide how to bring the decided design into existence.
- **Iteration and prototyping:** The iteration and prototyping step help in getting it right design by designing a sample and finding what is really needed!
- **Proximity:** When objects are near each other in space, our eyes and minds perceive them as belonging together.
- **Similarity:** If objects share a similar visual property, such as colour, size, shape, brightness, or orientation, our eyes and minds perceive them as belonging together.
- **Computer literacy:** Highly technical or experienced, moderate computer experience, or none.
- **System experience:** High, moderate, or low knowledge of a particular system and its methods of interaction.
- **Application experience:** High, moderate, or low knowledge of similar systems.

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5.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. List the types of user interface.
2. What are the steps involved in UI design process?
3. State the significance of prototyping.
4. What is the difference between short term and long term memory?
5. What is mental model?

Long-Answer Questions

1. Discuss about user interface and its various types giving suitable examples.
2. Elaborate on the process of UI design with the help of a diagram.
3. Explain the concept of human interaction speed giving appropriate examples.
4. Elaborate on human consideration in UI design giving examples.

5.10 FURTHER READINGS

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UNIT 6 GRAPHICAL USER INTERFACE-POPULARITY OF GRAPHICS

Structure

6.0 Introduction
6.1 Objectives
6.2 Graphical User Interface
  6.2.1 Graphical User Interfaces
  6.2.2 Widget Toolkit
  6.2.3 Characteristics of Graphical User Interface
6.3 Concepts of Direct Manipulation of Graphical User Interface
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6.0 INTRODUCTION

The graphical user interface is a form of user interface that allows users to interact with electronic devices through graphical icons and audio indicator, such as primary notation, instead of text-based user interfaces, typed command labels or text navigation. GUIs were introduced in reaction to the perceived steep learning curve of Command Line Interfaces (CLIs), which require commands to be typed on a computer keyboard.

The actions in a GUI are usually performed through direct manipulation of the graphical elements. Beyond computers, GUIs are used in many handheld mobile devices, such as MP3 players, portable media players, gaming devices, smartphones and smaller household, office, and industrial controls. The term GUI tends not to be applied to other lower-display resolution types of interfaces, such as video games where Head-Up Display (HUD) is preferred, or not including flat screens, like volumetric displays because the term is restricted to the scope of two-dimensional display screens able to describe generic information, in the tradition of the computer science research at the Xerox Palo Alto Research Centre.

The Web User Interface (Web UI or WUI) is the simple form of management for using the Web pages. The Wen UI menu can be either Dynamic Hyper Text Markup Language (DHTML) based, the default, or Java based. Though the functionality of both the types is identical, but the look and feel are slightly different.

By default, the Web UI is typically configured to work using only the Hyper Text Transfer Protocol (HTTP). However, it can be configured to work over HyperText Transfer Protocol Secure (HTTPS). This provides a secure mechanism to the Web management traffic. Most of the popular Web browsers, such as Internet Explorer, or Firefox work smoothly with it.

In this unit, you will study about the graphical user interface, concepts of direct manipulation of graphical user interface, various characteristics of graphical user interface, importance of user interface, Web user interface and characteristics and popularity of user interface.

6.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of graphical user interface
- Interpret the concepts of direct manipulation of graphical user interface
- Discuss the various characteristics of graphical user interface
- Understand the importance of user interface
- Learn about the Web user interface
- Discuss the characteristics and popularity of user interface

6.2 GRAPHICAL USER INTERFACE

The user interface or Human Computer Interface (HCI) is the collective means by which a human being interacts with a computer system including a peripheral device, a computer program or the computer itself. Normally, the user interface offers a process of *input* by which the user can influence and control a system; and the *output* whereby the system indicates the effect of the manipulation. For instance, in the earlier days of the mainframe computers, an input to the computer system was given mainly by typing commands on the console or by punch cards, and the output was obtained at the display terminals and on paper.

Early computer operating systems and applications used what is known as command line interface. Here, text was the only medium for interaction with the terminals as the user was restricted to give commands through the keyboard in a single line of text on the screen, called the command line. This mode of interface is also known as text-based interface. Even before that, in the primitive days of computers, the user had to enter a range of addresses through register switches to give commands and supply data.

Now, we have multimedia user interfaces or computer interfaces that communicate with a user using multiple media objects, such as image icons, text, speech, etc.

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6.2.1 Graphical User Interfaces

Graphical User Interfaces (GUIs) are the most popular type of computer interfaces today. They can be used intuitively and are much easier to use than the command-line interfaces. The user can interact with on screen simulations of familiar objects that give idea about the function of the application they represent. For instance, the icon of a calculator indicates a calculating program or a recycle bin (or a trash can) indicates the folder containing the deleted files.

The main features of a GUI interface are—on-screen desktop, display windows, options menu, command icons, dialog boxes and online help. The above features are briefly discussed as follows:

The *on-screen desktop* is the screen you normally see in your PC— it emulates your working table in real life. The various graphic elements, such as application icons, buttons, links, dialog boxes and sub-windows are displayed on the desktop.

The main feature of a GUI is the *display window.* It a rectangular area of the screen used to display a program or various types of output including multimedia data. There is a horizontal bar called the title bar at the top of each window that displays the name of the application and the file accessed in the display window. Multiple display windows may be opened for running multiple programs and applications in a multitasking environment. The display window also features a scroll bar at the side or bottom to scroll through a large document.

An *option menu,* as the name suggests provides a set of options. Users can select options they want by highlighting the option and clicking on it with the mouse, as in the case of selection of the text font or font size in the MS-Word program.

The *command icons* GUIs are icons representing common actions, such as opening, saving or printing files. These icons may be displayed in a row near the top of the screen called a toolbar. When the mouse pointer is positioned on an icon, the screen tips a one or two-word identification label is displayed. Clicking the icon launches the associated action.

A *dialog box* is a window that appears temporarily for the user to input specific information at run time. It disappears once the user enters the requested information. GUIs routinely use dialog boxes to prompt user responses and provide information. Interactions between the user and software are carried out through common GUI elements, such as text boxes, check boxes, tabs, option and buttons, etc.

The GUI interface also offers *online help* feature. Clicking the help button causes a dialog box to appear asking the user to specify the kind of help needed. The program then searches from either the client machine or online documentation and displays a menu of topics from which a user can make a selection.

It should be kept in mind that the GUIs were made possible with the introduction of mouse technology and multimedia high-resolution monitors. The other variants of the mouse are light pen, track ball and the touch screen. Today, almost all PCs are equipped with a preinstalled GUI operating system, and most application software is designed to work smoothly with them. Xerox PARC as the interface for the Xerox Alto computer introduced the concept of GUI. Apple Inc. made GUI popular with its Macintosh line of computers in early 1980s. At present Microsoft Windows is one of the most widely used GUI operating systems. The GUI consists of graphical window gadgets (WIDGETS), such as windows, menus, check boxes, radio buttons, and icons and utilizes a pointing device, such as a mouse, light pen or touch screen over and above the keyboard. The user can use the pointing device, such as mouse, touch screen, light pen, etc., to interact with both the textual and graphical objects by clicking, moving, dragging over the objects. The GUI is sometimes also referred to as WIMPS that is **W**indows, **I**cons, **M**ouse, and **P**ointer. GUI interfaces have become an essential component of multimedia applications. The other operative systems, such as UNIX also offer GUI interface with the X-Windows system. Also, programming languages, such as Java and C have also adopted GUI interface through external APIs though they were originally textual in nature.

Today GUI has evolved as a separate discipline that involves technological issues, such as the use of multimedia hardware elements to use text, image and audio based commands as well as understanding of human cognition to make the interface meaningful and memorable and easy to learn. Also, the GUI should be implementable without too much cost involvement.

6.2.2 Widget Toolkit

Widget toolkit is a collection of widgets, often implemented as a library, for a specific user-computer interaction. The widget toolkits are used for designing applications with GUIs. A typical widget toolkit contains the graphical interface element, such as the text box, check box, button, radio buttons, icons, menu, window, toolbars, scroll bars, etc.—using which a user interacts with the computer. Some of the widgets in a widget toolkit helps in interaction with the user, such as the check boxes, buttons, etc, while some widgets function as containers that contain a group of widgets attached to them, such as windows and panels.

The widget toolkit itself is software with an API that is generally provided with an OS or Window Manager. The widgets in a widget toolkit should adhere to a uniform look and feel (design specification) so that the user in general feels a sense of consistency among various portions of the application, as well as various applications within a GUI.

The GUI for a program may be constructed by adding widgets on the top of existing widgets in a cascading manner. For instance, the desktop is itself a widget, over which several widgets (such as toolbars, etc.) may be added or

removed. In many implementations, separate application windows may be added on the desktop by the Window Manager, each window being associated with a particular application containing a group of widgets (such as tool bar, scroll bars etc.), which can be viewed and accessed by the applications. Often the low-level widgets are integrated with the OS and interact directly with the OS while the high-level widgets come as separate application program. When the widget is activated (by the click of a mouse on a radio button, for example), an event is detected, and it is passed onto the application.

Among those integrated within the OS are the windows API for Microsoft Windows, the Mac OS toolbox and Apple Macintosh. Examples of high-level widget toolkits for UNIX are GTK+ and Motif used in desktop environment for the X-Window system. Microsoft uses the Microsoft Foundation Classes (MFC) for its own programs and also Windows Forms (which are .NET classes) for handling GUI controls. Qt is another widget toolkit that is available across different platforms like Windows, Macintosh and UNIX platforms. Cross platform toolkits for Java programming includes the standard window toolkit (SWT) and Abstract Window Toolkit (AWT) and more recently Swing from Sun Microsystems.

GTK+

GTK+ is a widget toolkit used for constructing GUI interfaces. It is one of the most popular widget toolkits for the X-Window System, along with Qt. It is used in the Gnome Desktop GUI as the widget toolkit and forms the base of the Gnome desktop. The important features of GTK+ are its flexibility to change the look and feel of the GUI, the ability to render smooth anti-aliased graphics, support for object-oriented programming support, extensive support of Unicode character sets (it supports international characters using UTF-8), elegant text rendering and layout using *Pango* and accessibility ATK. The flexibility of GTK+ allows GNOME applications to be ported on other OS platforms, such as Windows and Mac OS X. Also, The GTK+ library can be used by many programming languages like C++, C, Java, Perl, Python, PHP, etc., which has made it very popular as a cross platform widget toolkit. GTK+ is free software and is licensed under the Lesser General Public License (LGPL) as a part of the GNU Project. The current version of GTK+ is GTK+2, which is however not compatible with the earlier version.

Qt

Qt is a cross-platform application development framework. It is used both as a widget toolkit for GUI program development, and also for non-GUI programs, such as console tools, etc. Qt was developed by a Norwegian company Trolltech, and was subsequently acquisitioned by Nokia in 2008. Qt uses an extended version of C++ but allows binding with PHP, Java, Python, etc. Qt is available as free, open source software distributed under the GNU Lesser General Public License (LGPL). Apart from being a widget toolkit, Qt also supports non-GUI features,

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such as APIs for file handling across different platforms, SQL database access, XML parsing, etc., and multithreaded applications. Five different varieties of Qt are available for various platforms as follows:

- Qt for Linux/X11 for X Windows
- Qt for Mac OS X for Apple Macintosh OS X
- Qt for Windows for Microsoft Windows
- Qt for embedded LINUX for embedded Linux in mobile equipments, such as PDAs
- Qt for Windows free edition (a free version for Windows)

X-Window system

The X-Window system (or X) is a standard widget toolkit and network protocol to build GUI capabilities on UNIX-based networked computers. Primarily, it is a protocol and definition of graphics primitives. It does not dictate the styles of the GUI elements (widgets), such as tool bars, windows, buttons, etc., but let the individual client programs handle this. As a result, the look and feel of X-based environments differ widely and different programs using X present drastically different interfaces. In UNIX, the GUI is not built as the part of the OS kernel, so the X is built as an additional application layer on top of the OS kernel. It provides basic capabilities, such as working with desktop windows and interacting via the mouse pointer. It was initially developed as part of Project Athena. The X.org Foundation maintains the open source version of X-Windows. The X Window system in its present form offers a standard toolkit and protocol stack for building GUI on UNIX or most UNIX-like operating systems. Desktop environments, such as GNOME, KDE and CDE use the X Window System.

Another important aspect of X is that it is specifically designed to function in client-server model over network connections. However, in this client-server model adopted by X, the nomenclature is reversed, as the user machine is the server while the applications running are the clients. This may be a bit confusing. However, remember that X looks from the perspective of the application. Since it provides display and I/O services to the application, it takes the role of the server, and the application that uses these services and is thus clients.

The design of X implies the clients and server to work separately, thus increasing the overhead and decreasing the performance. The current protocol version of X is *X11* that was released in 1987.

Motif

Motif is a GUI guideline as well as a widget toolkit (the Xm or motif widgets) for building GUI under the X-Window system. Motif also includes the documentation called motif style guide that tells how a motif user interface should look and behave

to be *motif compliant*. It is also an industry standard known as IEEE 1295. It was created by the open software foundation that has now become the open group. Its current version 2.1 provides support for Unicode and is widely used in several multilingual applications. It is distinguished by its three-dimension look for various widgets or user interface elements, such as text boxes, menus, buttons, sliders, etc. Many consider it to be obsolete in comparison to GTK+ and Qt, which is true to some extent. In fact, Sun Microsystems, a major motif user has switched over to GTK+.

6.2.3 Characteristics of Graphical User Interface

The Graphical User Interface (GUI) or Human Computer Interface (HCI) is the aggregate of means by which the users interact with the system, a particular machine, device, computer program or other complex tools. The user interface provides means of:

I. Input, allowing the users to manipulate a system.

II. Output, allowing the system to produce the effects of the users' manipulation.

A GUI can also be simply defined as a combination of components which enables computer users to directly interact with the computer system and control computer programs. Devices used to interact with the computer could be input devices like mouse, keyboard, touch pad, digital pen and output devices like computer monitor, touch screens and audio devices. It is basically a combination of graphical, audio and textual presentation of information by the program to a user and the users control sequence, i.e., punching of keystrokes, moving of mouse and pressing the touch screen options by the user to control the program.

Further developments in the input and output devices for computers, predominantly the increased quality of monitors and displays changed the way users interacted with computers through the introduction of the Graphical User Interface (GUI). This displays pictorial output on your computer monitor, which is interacted via a mouse and keyboard. This makes general control and interaction simpler and more intuitive for the user and reduces the need to remember text commands. Initiated by Apple Mac and later on standardized by MS Windows, GUI is a widely used User Interface. This image shows the interface from the first home GUI computer, the Apple Mac released in 1984.

GUIs have evolved considerably to the extent that now it seems almost inconceivable how users ever worked on CLI (Command Line Interface). GUI have not only made it much more easier for users to work on computers but has made it possible for millions of people who have no prior background or desire to learn information technology to use computers for their day to day work. So whether you are a doctor or an engineer or a chartered accountant or novelist due to the ease of working through the GUI, you can use the computers to do your job better and faster.

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The GUI includes the feel of multimedia parts, such as motion video, sound, virtual reality interfaces that becomes the part of GUI applications. A system GUI is sometimes referred to 'look-and-feel' guarantee. The OS manages the resources in a system unit, such as disk drive, internal memory, mouse printers and network connections. The OS along with GUI is populated WIMP (Windows, Icons, Menus and Pointers) interfaces. The designers of OS keeps command shell for restricted uses, such as checking the system files and ping the workstations to find the network connectivity.

6.3 CONCEPTS OF DIRECT MANIPULATION OF GRAPHICAL USER INTERFACE

With the rapid evolution of software technology the human computer interaction has become so natural and intuitive nowadays that it hardly needs any training or instructions as to how to use a particular software. Interactive *Graphical User Interface* or *GUI* developed using computer graphics technique is the one that has revolutionized the mode of communication between the user and the computer. Graphics based user interfaces with objects and dialogs that closely correspond to the users normal perception and their mental model of the system makes life easier for the user. People are no longer interested in the technology behind the computer; they simply want a tool that is easy to use and can help them solve their problems effectively without requiring to learn much about the software. A good GUI certainly helps to satisfy users in this respect. Let us now learn some basic components of GUI and tips for designing a good GUI.

GUI Elements

Dialog Box and Window

The term 'Window' refers to any rectangular screen area that provides application specific workspace or presents information or objects and can be moved about, resized and made active or inactive. Every window contain menus and icons for selection of processing options and parameter values. Dialog box is a type of window and is invoked by an application when multiple inputs are required to specify the desired action. A dialog box may contain different controls like, radio button, command button, list box, check box, spin box, slider, etc.

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Table 6.1 *Types of Dialog Boxes*

Type	Description	Use	Example
Modal	Dialog box	Presentation of a finite task	File Open dialog box Save As dialog box
Modeless	Dialog box	Presentation of an ongoing task	Search dialog box History List dialog box Task List dialog box
Application Window	Window frame with document (child) windows contained within	Presentation of multiple instances of an object, Comparison of data within two or more windows	Word Processor Spreadsheet
Document Window	Modeless dialog box or document window contained within and managed by Application window	Presentation of multiple parts of an application	Multiple views of data (sheets)
Secondary Window	Primary window of a secondary application	Presentation of another application called from parent	Invoke Help within an application

Multiple Windowing

In a multi-window environment like that of WINDOWS we frequently work through a window interface while keeping other windows open - one over the other in different positions on the screen. Only the active window i.e., the one where the user interacts remains at the top, thus overlapping and obscuring content of the other windows just behind it. This overlapping occurs amongst the windows depending on the display priorities or order of appearances.

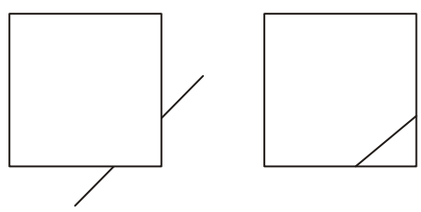

Fig. 6.1 *Multiple Windowing*

Basically multiple windowing is a result of both interior and exterior clipping. So far we have discussed only ***interior clipping*** whereby everything outside the clipping region is eliminated and the objects or part of objects inside the clipping region are identified and drawn. The reverse of this process i.e. to determine what portion(s) of display lie outside a clipping region and to draw those exterior portions only is called ***exterior clipping.***

In Fig. 6.2 windows 1, 2 and 3 have priorities over the background or display window and priority increases from windows 1 to 3 with window 3 having the top most priority. Consequently the background data is clipped to the interior of the display (screen) boundary itself and to the exterior of each of the windows 1, 2 and 3. Data in window 1 is clipped to the interior of the window itself and to the exterior of windows 2 and 3. Data of window 2 is clipped w.r.t self-interior

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and w.r.t the exterior of window 3. The content of window 3 undergoes interior clipping only. Thus in multiple windowing objects within a window are clipped to the interior of that window. When other high priority windows overlap these objects, the objects are also clipped to the exterior of the overlapping windows.

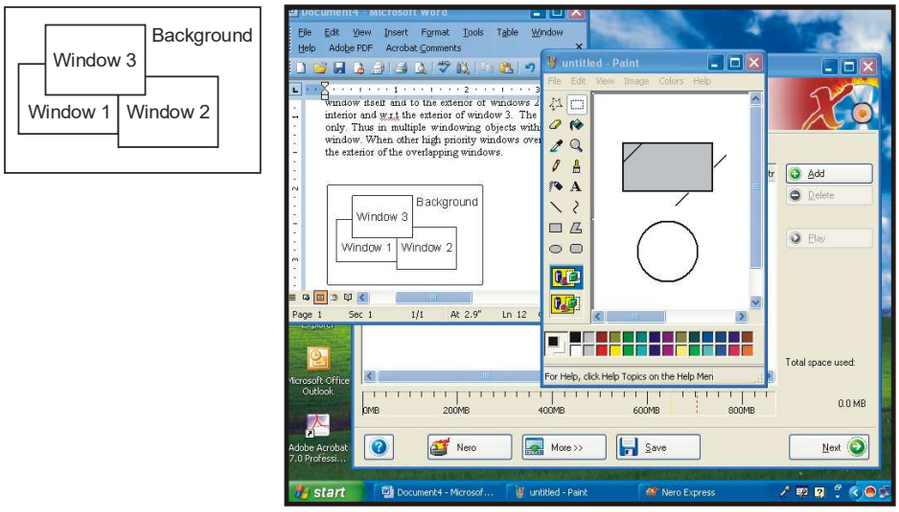

Fig. 6.2

The same basic procedures for interior clipping can be used for exterior clipping with little bit modification of the algorithm. However, it is important to identify whether a point lie outside or within the clipping window before applying appropriate clipping algorithm in case of multiple windowing.

Icon

Icons are symbolic representation of some object or process. The process triggers off when corresponding icons are clicked with mouse or activated through keyboard. Icons are primarily used to speed up interaction with user. Icons enhance the visual attractiveness of an application since the user is cognitively tuned to pictures. In an application that is text oriented, icons may be less effective. Generally icons occupy less screen space then equivalent text.

Icon Guidelines

- Represent the object in a familiar and recognizable manner.
- Limit the number of different icons.
- Make the icon stand out from its background.
- Ensure that a single selected icon is clearly visible when surrounded by unselected icons.
- Make each icon distinct and easy to discriminate from every other icon.
- Ensure the harmony of each icon in a family.
- Design the movement animation when an icon is dragged and dropped.

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Pull-Down and Cascaded Menus

A menu displays a list of commands. When menus are located on the menu bar at the top of an application window, these are known as Pull-Down menus. The name is derived from the fact that each of these menus are like rolled up screens and when clicked with mouse the roll unfolds downward showing all the commands or submenus within it. The submenus that have multiple options under it are denoted by an arrowhead symbol (▶) beside it and are known as Cascaded menu. Users may need to explore the menubar to pick the correct menu and then pull it down to finally pick the desired option under a cascaded submenu.

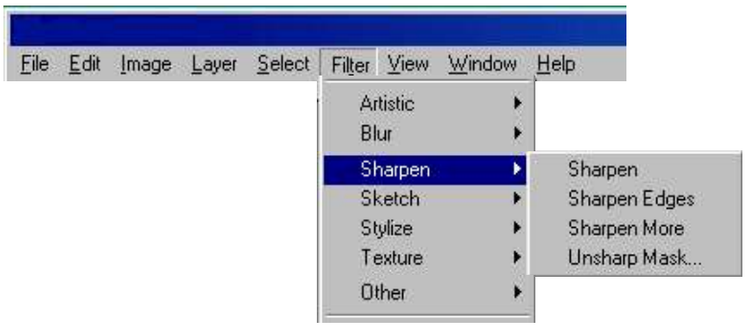

Fig. 6.3 *Pull-Down and Cascaded menus*

Menu Guidelines

- Exploring a particular option in the pull-down menu structure requires a lot of 'mousing around'; this may irritate or confuse a naive or infrequent user. Using labeled buttons or toolbar[1] (with dynamic tooltips) is a better alternative.

Fig. 6.4 *Menu guidelines*

- Provide a traceable path of navigation in the menu structure so that the user is not trapped in a stage of no return. Providing a descriptive title bar within each dialog box will help greatly to remind the user what menu items or buttons were pressed to bring them to the window now in focus.
- The menu structure should be as flat and intuitive as possible and more than two levels of cascading menus should be avoided. Don't demand too much from the user in memorizing relationship among the menus and pull-down options.
- Since pull-downs hide options, users must know that they exist! Research demonstrates that users forget rapidly and often fail to search under menu options for ideas.

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- System-wide functions that are used least frequently should be the first choice for inclusion in the pulldown category.
- When using pull-downs, never change menubar names! If an option doesn't apply in a particular situation, deactivate it by dimming it rather than hiding it.
- Use pull-downs when your task consumes the screen space for a major object like a text edit window (word processing) or large metaphor (spreadsheet), etc. Pull-downs can greatly save screen space.

Command Button

Command Button is used

- To trigger a process.
- To accept or cancel input.
- To set a button as default (activated by pressing ENTER key) if it triggers the most frequent action.

Fig. 6.5 *Command button*

Option (Radio) Buttons

Option Button is used

- To select a single choice from a list of options.
- If the operation is primarily mouse driven.
- If one choice is always required.
- To set a default option (generally the most frequent action).

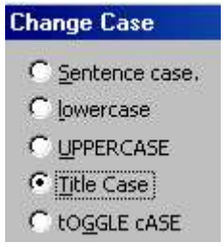

Fig. 6.6 *Option buttons*

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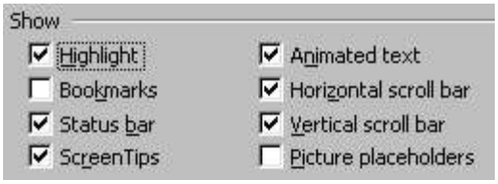
Check Boxes

Check box is used

- To select more than one choice from a list of options.



- To set a binary choice (check if YES; uncheck if NO)

Fig. 6.7 *Check boxes*

Text Fields

Text Field is used

- To enter text data.
- To set fields to length of corresponding data.

List Boxes

List Boxes have the following applications

- To make a single or multiple choice from a long list.
- To make a single choice from a drop-down list box when space is limited.
- To scroll a list with associated accumulator box for multiple choices from a long list.
- *Combo box* (drop down list/text edit field) is used for selecting from list or entering of items not on list.

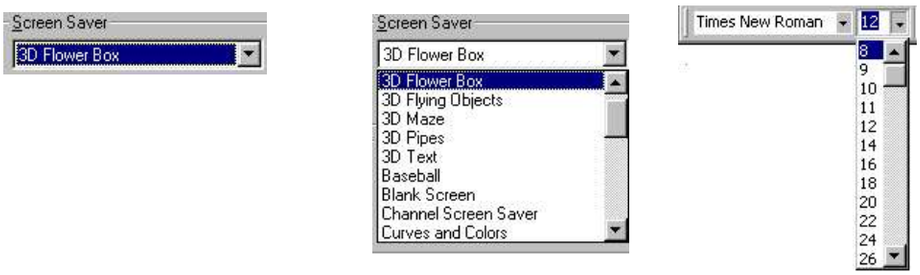


Fig. 6.8 *List boxes*

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Spin Boxes

Fig. 6.9 *Spin boxes*

Spin Boxes are used

- To select limited choices of predictable values (days of week, months of year).
- In combination with text edit field to allow data entry if keyboard is primarily used.

Slider

Slider is used

- To set a data value by viewing dynamically the entire data range by dragging the slider along a channel.

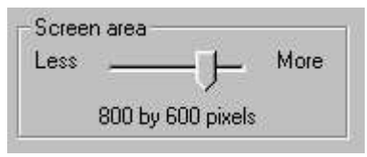

Fig. 6.10 *Slider*

The above elements are also known as *Controls*. GUI designers are faced with an unending array of controls to choose from. Choosing the appropriate control for each user task will result in higher productivity, lower error rates, and higher overall user satisfaction. The following table may be referred as a guideline for using controls in windows.

Table 6.2 *Guideline for Using Controls in Windows*

Control	Optimum number of choices in domain shown
Menu Bar	Maximum 10 items
Pull-Down Menu	Maximum 12 items
Cascading Menu	Maximum 5 items, 1 cascade deep
Push-button	1 for each button, maximum of 6 per dialog box
Check Box	1 for each box, maximum of 10 to 12 per group
Radio Button	1 for each button, maximum of 6 per group box
List Box	50 in list, display 8 to 10 rows
Drop-down List Box	Display 1 selection in control at a time, upto 20 in a drop-down box
Combination List Box	Display 1 selection in control at a time in standard format up to 20 in a drop-down box
Spin Box	Maximum 10 values
Slider	Dependent on data displayed

Reserved Words

One effective way to increase the clarity of GUI applications is to develop and use a list of reserved words. Also keep provision for using shortcut keystrokes, mnemonic keystrokes, 'hot keys' and function keys for fast access of menus and buttons.

Table 6.3 *List of Reserved Words*

Text	Function	Appears on button	Appears on menu	Mnemonic keystrokes	Shortcut keystrokes
OK	Accept data entered or acknowledge information presented and remove the window	Yes	No	None	<Return> or <Enter>
Cancel	Do not accept data entered and remove the window	Yes	No	None	Esc
Close	Close the current task and continue working with the application; close view of data	Yes	Yes	Alt+C	None
Exit	Quit the application	No	Yes	Alt+X	Alt+F4
Help	Invoke the application's Help facility	Yes	Yes	Alt+H	Fl
Save	Save data entered and stay in current window	Yes	Yes	Alt+S	Shift+Fl2
Save As	Save the data with a new name	No	Yes	Alt+A	F12
Undo	Undo the latest action	No	Yes	Alt+U	Ctrl+Z
Cut	Cut the highlighted characters	No	Yes	Alt+T	Ctrl+X
Copy	Copy highlighted text	No	Yes	Alt+C	Ctrl+C
Paste	Paste the copied or cut text at the insertion point	No	Yes	Alt+P	Ctrl+V

Guidelines for Designing an Effective Graphical User Interface

- One very important characteristic of good GUIs is speed, or more specifically, responsiveness. Many speed issues are handled via the design of the GUI, not the hardware. Depending on the type of application, speed can be the make-or-break factor in determining an application's acceptability in the user community. You can give a GUI the appearance of speed in several ways. Avoid repainting the screen unless it is absolutely necessary. Another method is to have all field validations occur on a whole-screen basis instead of on a field-by-field basis. Other speed features include mnemonics, accelerator keys, toolbar buttons etc.
- Ensure that users work is carefully and continuously saved, with full option for the user to undo any activity at any time. Sometimes people want to find out what would happen if they carried out some potentially dangerous action; sometimes they do it by accident. By making actions reversible, users can explore freely.
- Fields containing defaults should come up selected, so users can replace the default contents with new material quickly and easily.

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- Use easy view status mechanisms to keep users aware and informed of the ongoing task and the work environment. Users should not have to seek out status information.
- GUI controls should be positioned according to frequency of use. The most important field should be in the upper left; the least important field should be in the lower right.
- Use large objects for important functions (big buttons are faster).
- Use blank space to group and organize your fields and data. Don't feel obliged to completely fill the screen with fields and data. 70% white space is very acceptable. For strongly organized data (e.g., tables), 30% white space is okay.
- Text that must be read should be displayed with high contrast for better readability. Use large font sizes.
- Developers often try to make textual feedback clear by adding a lot of words. However, they ultimately make the message less clear. Concise wording of text labels, error messages, and one-line help messages is challenging.
- Display an hourglass for any action that will take from 1/2 to 2 seconds. Animate the hourglass so they know the system hasn't died. Display a message indicating the potential length of the wait for any action that will take longer than 2 seconds. Communicate the actual length through an animated progress indicator. Your users will greatly appreciate knowing how much longer a given operation will take before they can enjoy the fruits of their patience.
- Provide audible feedback in cases where you need to warn the user of an impending serious problem, such as one in which proceeding further could cause loss of data or software.
- Most users get surprised and disoriented when an error message appears instantaneously. Match expectations by adding a delay before displaying an error message.
- Acknowledge all button clicks by visual or aural feedback within 50 milliseconds.
- Trap multiple clicks of the same button or object. Users are generally impatient and tend to press the same button repeatedly if the output is delayed, sometimes causing things to be even slower.
- Avoid the temptation to put everything on the first screen or load the toolbar with rarely used buttons. At the same time ensure that features used frequently are readily available.
- Always attempt to provide a list of data values to select from rather than have the users key in values from memory. The average person can recall

about 2,000 to 3,000 words, yet can recognize more than 50,000 words.

- Good GUIs apply consistent behavior throughout the application and build upon user's prior knowledge of other applications. On the basis of users' experiences with one screen or one dialog box, they should have some sense of how to interact with the next screen or control if the design is consistent. Never attempt to change the basic behaviour of the standard controls.
- Applications should attempt to anticipate the user's wants and needs. Do not expect users to search for or gather information or evoke necessary tools. Bring to the user all the information and tools needed for each step of the process.

Finally it can be said that designing good GUIs is a critical skill for application developers, regardless of the GUI platform in which they are designing. Good GUI designs don't happen naturally. The developer must learn and apply some basic principles. While designing a GUI the objective should be to create a design a user will enjoy working with every day. The developer must have as much experience as possible in working on and using good GUI designs.

Check Your Progress

1. Define the term user interface or Human- Computer Interface (HCI).
2. List the main features of a GUI interface.
3. State the significance of on-screen desktop.
4. Why are the widget toolkits used?
5. What is GTK+ widget toolkit?

6.4 WEB USER INTERFACE - CHARACTERISTICS AND POPULARITY

The Web User Interface (Web UI or WUI) is the simple form of management for using the Web pages. The Web UI menu can be either Dynamic HyperText Markup Language (DHTML) based, the default, or Java based. Though the functionality of both the types is identical, but the look and feel is slightly different. By default, the Web UI is typically configured to work using only the HyperText Transfer Protocol (HTTP). However, it can be configured to work over Hypertext Transfer Protocol Secure (HTTPS). This provides a secure mechanism to the Web management traffic. Most of the popular Web browsers, such as Internet Explorer, or Firefox work smoothly with it.

A Web UI or Web app permits the Web users to interact with the content or software that runs on a remote server through a Web browser. The content or Web page can be downloaded from the Web server and the Web user can interact

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with this Web content in a typical Web browser, which acts as a client. The most commonly used Web applications are Webmail, online shopping, online document sharing, social media, instant messaging, etc. With the help of these interfaces types, huge amount of online data is generated.

Popularity of Web

The evolution of the Graphical User Interface (GUI) has revolutionized the User Interface (UI), and the introduction of Web has revolutionized computing. Web permits millions of people across the globe to communicate, access information, publish, and much more. It also permits people to control the Web display and the rendering of Web pages. This popularity has been reflected through the usage of Web. The number of Internet hosts has increased histrionically.

Users are becoming much more discern about good Web design. Slow download times, confusing navigation, confusing page organization, disturbing animation, or other undesirable site features often results in user abandonment of the site for others with a more agreeable interface.

6.4.1 Functions and Characteristic Features of the Web User Interface

The Web User Interface (WUI) provides an easy-to-use interface that can be used to perform all of the operational and administrative tasks essential to monitor and control Web or online resources. The user can link to the Web UI from any location that can launch a Web browser.

The WUI is supplied with a set of linked menus and views to facilitate all your system management tasks. You can also customize the WUI to reproduce and redesign your business procedures that best suits the essentials of the individual users.

The WUI features helps you in:

- Creating clear, uncluttered menus and displays (called views), that only provide the essential information that the user can view.
- Structuring your data in a task-oriented method.

Additionally, you can:

- Organize the User Interface (UI) by resource category, by user task or by application.
- Define the links between views.
- Describe the buttons that will appear on a display and also the functions of these buttons.
- Customize the layout of the data.

There is no limit to number of views, i.e., you can have as many views of the similar object as you require. Each one of the view shows a different selection of data depending on the user task.

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You can customize the text data and the appearance of views as per your business requirements. Specify the details and define essential text information about the action buttons in view menu.

For each selected menu, add explanatory or descriptive text to help the user in the task. Display only the information that you want to be viewed by the user.

Keep your Web UI secure by following the respective guidelines and control policies. The users should be given the rights to view the information, send queries to get more required information and place orders. The users should not be given rights to modify or amend the information. Set the WUI secure displaying the copyright acts and pop-up warnings if the user tries to open a secured and sensitive WUI view. Protect the view editor, user editor and specific menus, views and help panels from unauthorized access. Additionally, you can also improve the performance of your WUI by reducing unnecessary waits.

Web UI also facilitates you to develop your customised and company specific Web page through which you can provide your own personalised and custom-made help information for each view and menu either in the national language or regional language.

Check Your Progress

6. Define the term icon.
7. Name one important characteristic of good GUI.
8. What is the role of Web User Interface (WUI)?
9. What should be the objective while designing a GUI?

6.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The user interface or Human Computer Interface (HCI) is the collective means by which a human being interacts with a computer system including a peripheral device, a computer program, or the computer itself.
2. The main features of a GUI interface are on-screen desktop, display windows, options menu, command icons, dialog boxes and online help.
3. The on-screen desktop is the screen you normally see in your PC, it emulates your working table in real life. The various graphic elements, such as application icons, buttons, links, dialog boxes and sub-windows are displayed on the desktop.

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4. The widget toolkits are used for designing applications with GUIs. A typical widget toolkit contains the graphical interface element, such as the text box, check box, button, radio buttons, icons, menu, window, toolbars, scroll bars, etc.
5. GTK+ is a widget toolkit used for constructing GUI interfaces. It is one of the most popular widget toolkits for the X-Window System, along with Qt. It is used in the Gnome Desktop GUI as the widget toolkit and forms the base of the Gnome desktop.
6. Icons are symbolic representation of some object or process. The process triggers off when corresponding icons are clicked with mouse or activated through keyboard. Icons are primarily used to speed up interaction with user.
7. One important characteristic of good GUIs is speed, or more specifically, responsiveness. Many speed issues are handled via the design of the GUI, not the hardware.
8. The Web User Interface (WUI) provides an easy-to-use interface that can be used to perform all the operational and administrative tasks essential to monitor and control Web or online resources.
9. While designing a GUI the objective should be to create a design a user will enjoy working with every day. The developer must have as much experience as possible in working on and using good GUI designs.

6.6 SUMMARY

- The user interface or Human Computer Interface (HCI) is the collective means by which a human being interacts with a computer system including a peripheral device, a computer program, or the computer itself.
- Graphical User Interfaces (GUIs) are the most popular type of computer interfaces today. They can be used intuitively and are much easier to use than the command line interfaces.
- The main features of a GUI interface are—on-screen desktop, display windows, options menu, command icons, dialog boxes and online help.
- The on-screen desktop is the screen you normally see in your PC— it emulates your working table in real life.
- The main feature of a GUI is the display window. It a rectangular area of the screen used to display a program or various types of output including multimedia data.
- There is a horizontal bar called the title bar at the top of each window that displays the name of the application and the file accessed in the display window.

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- Multiple display windows may be opened for running multiple programs and applications in a multitasking environment.
- An option menu, as the name suggests provides a set of options. Users can select options they want by highlighting the option and clicking on it with the mouse, as in the case of selection of the text font or font size in the MS-Word program.
- The command icons GUIs are icons representing common actions, such as opening, saving, or printing files.
- A dialog box is a window that appears temporarily for the user to input specific information at run time.
- The GUI interface also offers online help feature. Clicking the help button causes a dialog box to appear asking the user to specify the kind of help needed.
- Xerox PARC as the interface for the Xerox Alto computer introduced the concept of GUI. Apple Inc. made GUI popular with its Macintosh line of computers in early 1980s.
- The user can use the pointing device, such as mouse, touch screen, light pen, etc., to interact with both the textual and graphical objects by clicking, moving, dragging over the objects.
- The GUI is sometimes also referred to as WIMPS that is Windows, Icons, Mouse, and Pointer.
- GUI interfaces have become an essential component of multimedia applications. The other operative systems, such as UNIX also offer GUI interface with the X-Windows system.
- Widget toolkit is a collection of widgets, often implemented as a library, for a specific user-computer interaction.
- The widget toolkits are used for designing applications with GUIs. A typical widget toolkit contains the graphical interface element, such as the text box, check box, button, radio buttons, icons, menu, window, toolbars, scroll bars, etc., using which a user interacts with the computer.
- The widget toolkit itself is software with an API that is generally provided with an OS or Window manager.
- The GUI for a program may be constructed by adding widgets on the top of existing widgets in a cascading manner.
- Qt is another widget toolkit that is available across different platforms like Windows, Macintosh, and UNIX platforms.
- Cross platform toolkits for Java programming includes the standard window toolkit (SWT) and Abstract Window Toolkit (AWT) and more recently Swing from Sun Microsystems.

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- GTK+ is a widget toolkit used for constructing GUI interfaces. It is one of the most popular widget toolkits for the X-Window System, along with Qt.
- Qt is a cross-platform application development framework. It is used both as a widget toolkit for GUI program development, and for non-GUI programs, such as console tools, etc.
- The X-Window system (or X) is a standard widget toolkit and network protocol to build GUI capabilities on UNIX-based networked computers.
- In UNIX, the GUI is not built as the part of the OS kernel, so the X is built as an additional application layer on top of the OS kernel. It provides basic capabilities, such as working with desktop windows and interacting via the mouse pointer.
- Motif is a GUI guideline as well as a widget toolkit for building GUI under the X-Window system.
- Motif also includes the documentation called motif style guide that tells how a motif user interface should look and behave to be motif compliant.
- The GUI includes the feel of multimedia parts, such as motion video, sound, virtual reality interfaces that becomes the part of GUI applications.
- The term 'Window' refers to any rectangular screen area that provides application specific workspace or presents information or objects and can be moved about, resized, and made active or inactive.
- Dialog box is a type of window and is invoked by an application when multiple inputs are required to specify the desired action.
- A dialog box may contain different controls like, radio button, command button, list box, check box, spin box, slider, etc.
- Icons are symbolic representation of some object or process. The process triggers off when corresponding icons are clicked with mouse or activated through keyboard.
- Icons are primarily used to speed up interaction with user. Icons enhance the visual attractiveness of an application since the user is cognitively tuned to pictures.
- A menu displays a list of commands. When menus are located on the menu bar at the top of an application window, these are known as pull-down menus.
- One important characteristic of good GUIs is speed, or more specifically, responsiveness.
- Depending on the type of application, speed can be the make-or-break factor in determining an application's acceptability in the user community.
- GUI controls should be positioned according to frequency of use. The most important field should be in the upper left; the least important field should be in the lower right.

- The Web User Interface (Web UI or WUI) is the simple form of management for using the Web pages.
- A Web UI or Web app permits the Web users to interact with the content or software that runs on a remote server through a Web browser.
- The evolution of the Graphical User Interface (GUI) has revolutionized the User Interface (UI), and the introduction of Web has revolutionized computing.
- The Web User Interface (WUI) provides an easy-to-use interface that can be used to perform all the operational and administrative tasks essential to monitor and control Web or online resources.
- The WUI is supplied with a set of linked menus and views to facilitate all your system management tasks.

6.7 KEY WORDS

- **Command icons:** GUIs are icons representing common actions, such as opening, saving, or printing files.
- **Dialog box:** It is a window that appears temporarily for the user to input specific information at run time.
- **Widget toolkit:** It is a collection of widgets, often implemented as a library, for a specific user-computer interaction.
- **X-Window system (or X):** It is a standard widget toolkit and network protocol to build GUI capabilities on UNIX-based networked computers.
- **Motif:** It is a GUI guideline as well as a widget toolkit for building GUI under the X-Window system.
- **Icons:** They are symbolic representation of some object or process.

6.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is the importance of Graphical User Interfaces (GUIs)?
2. Define the term option menu.
3. Why are command icons important?
4. What is GUI also referred as?
5. State the importance of widget toolkit.
6. Why is the GTK+ toolkit used?

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7. Define the term Qt.
8. What is an interior clipping?
9. Why is cascaded menu important?
10. Why is the check box is used?

Long-Answer Questions

1. Discuss the features of Qt. List the five different varieties of Qt.
2. Elaborate on Graphical User Interface (GUI) or Human Computer Interface (HCI). Also, name the characteristics of graphical user interface.
3. Discuss the various GUI elements with the help of suitable examples.
4. Discuss about the pull-down and cascaded menus and list all the menu guidelines.
5. Describe all the guidelines for designing an effective graphical user interface with the help of suitable examples.
6. What is Web user interface? Discuss its characteristics in brief.

6.9 FURTHER READINGS

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UNIT 7 DEVICE AND SCREEN BASED CONTROLS

NOTES

Structure

7.0 Introduction
7.1 Objectives
7.2 Device and Screen
7.3 Raster Scan Display
  7.3.1 Refresh Rate and Interlacing
  7.3.2 CRT
  7.3.3 Bit Planes, Color Depth and Color Palette
  7.3.4 Frame Buffer and Output Circuitry
7.4 Random Scan Display
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7.6 Device Based Controls
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7.9 Summary
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7.11 Self Assessment Questions and Exercises
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7.0 INTRODUCTION

Device-based controls, often called input devices, are the mechanisms through which people communicate their desires to the system. Device-based controls, often called input devices, are the mechanisms through which people communicate their desires to the system. A control system manages, commands, directs, or regulates the behaviour of other devices or systems using control loops.

Screen-based controls, often simply called controls and sometimes called widgets, are the elements of a screen that constitute its body. In the last decade, some platforms have expanded the definition of a control to include all specifiable aspects of a screen, including screen text, headings and group boxes. The screen designer is presented with an array of screen controls to choose from. Selecting the right one for the user and the task is often difficult. But, as with input devices, making the right choice is critical to system success. A proper fit between user and control will lead to fast, accurate performance.

In this unit, you will study about the device and screen based controls, operable devices, various types of device based controls, random scan display, direct view storage tube and selection controls.

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7.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of display devices
- Learn about operable controls
- Discuss the various device-based controls
- Understand the importance of random scan display
- Learn about the Direct View Storage Tube (DVST)
- Discuss about selection controls

7.2 DEVICE AND SCREEN

The most prominent part in a personal computer is the display system that is responsible for graphic display. The display system may be attached with a PC to display character, picture and video output. Some of the common types of display system available in the market are,

1. Raster Scan Displays
2. Random Scan Displays
3. Direct View Storage Tube
4. Flat Panel Displays
5. Three Dimensional Viewing Devices
6. Stereoscopic and Virtual Reality System

The display systems are often referred to as *Video Monitor* or *Video Display Unit (VDU)*. The most common video monitor that normally comes with a PC is the Raster Scan type. However, every display system has three basic parts – the *display adapter* that creates and holds the image information, the *monitor* which displays that information and the *cable* that carries the image data between the display adapter and the monitor.

Before we discuss the major display systems let us first know about some basic terms.

Pixel

A *pixel* may be defined as the smallest size object or color spot that can be displayed and addressed on a monitor. Any image that is displayed on the monitor is made up of thousands of such small pixels (also known as picture elements). The closely spaced pixels divide the image area into a compact and uniform two-dimensional grid of pixel lines and columns. Each pixel has a particular color and brightness value. Though the size of a pixel depends mostly on the size of the

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electron beam within the CRT, they are too fine and close to each other to be perceptible by the human eye. The finer the pixels the more the number of pixels displayable on a monitor-screen. However it should be remembered that the number of pixels in an image is fixed by the program that creates the image and not by the hardware that displays it.

Resolution

There are two distinctly different terms, which are often confused. One is *Image Resolution* and the other is *Screen Resolution*. Strictly speaking image resolution refers to the pixel spacing, i.e. the distance from one pixel to the next pixel. A typical PC monitor displays screen images with a resolution somewhere between 25 pixels per inch and 80 pixels per inch (ppi). In other words resolution of an image refers to the total number of pixels along the entire height and width of the image. For example a full-screen image with resolution 800 × 600 means that there are 800 columns of pixels, each column comprising 600 pixels, i.e. a total of 800 × 600 = 480000 pixels in the image area.

The internal surface of the monitor screen is coated with red, green and blue phosphor material that glows when struck by a stream of electrons. This coated material is arranged into an array of millions of tiny cells—red, green and blue, usually called *dots*. The *dot pitch* is the distance between adjacent sets (triads) of red, green and blue dots. This is also same as the shortest distance between any two dots of the same color, i.e. from red-to-red, or, green-to-green like that. Usually monitors are available with a dot pitch specification 0.25 mm to 0.40 mm. Each dot glow with a single pure color (red, green or blue) and each glowing triad appears to our eye as a small spot of color (a mixture of red, green and blue). Depending on the intensity of the red, green and blue colors different colors results in different triads. The dot pitch of the monitor thus indicates how fine can be the colored spots that make up the picture, though electron beam dia is an important factor in determining the spot size.

So we understand that pixel is the smallest element of a displayed image, and dots (red, green and blue) are the smallest elements of a display surface (monitor screen). The dot pitch is the measure of screen resolution. The smaller the dot pitch, the higher the resolution, sharpness and detail of the image displayed.

In order to use different resolutions on a monitor, the monitor must support automatic changing of resolution modes. Originally, monitors were fixed at a particular resolution, but for most monitors today display resolution can be changed using software control. This lets you use higher or lower resolution depending on the need of your application. A higher resolution display allows you to see more information on your screen at a time and is particularly useful for operating systems such as Windows. However, the resolution of an image you see is a function of what the video card outputs and what the monitor is capable of displaying. To see a high resolution image such as 1280x1024 requires both a video card capable of producing an image this large and a monitor capable of displaying it.

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Image Resolution versus Dot Pitch

If the image resolution is more compared to the inherent resolution of the display device then the displayed image quality gets reduced. As the image has to fit in the limited resolution of the monitor, the screen pixels (comprising a red, a green and a blue dot) show the average color and brightness of several adjacent image pixels. Only when the two resolutions match, the image is displayed perfectly and only then the monitor is used to its maximum capacity.

Aspect Ratio

The *aspect ratio* of the image is the ratio of the number of X pixels to the number of Y pixels. The standard aspect ratio for PCs is 4:3, and some resolutions even use a ratio of 5:4. Monitors are calibrated to this standard so that when you draw a circle it appears to be a circle and not an ellipse. Displaying an image that uses an aspect ratio of 5:4 will cause the image to appear somewhat distorted. The only mainstream resolution that uses 5:4 is the high-resolution 1280 × 1024.

Table 7.1 *Common resolutions, respective number of pixels and standard aspect ratios*

Resolution	Number of Pixels	Aspect Ratio
320 × 200	64,000	8:5
640 × 480	307,200	4:3
800 × 600	480,000	4:3
1024 × 768	786,432	4:3
1280 × 1024	1,310,720	5:4
1600 × 1200	1,920,000	4:3

7.3 RASTER SCAN DISPLAY

This type of display basically employs a *Cathode Ray Tube (CRT)* or *LCD Panel* for display. The CRT works just like the picture tube of a television set. Its viewing surface is coated with a layer of arrayed phosphor dots. At the back of the CRT is a set of electron guns (cathodes) which produce controlled stream of electrons (electron beam). The phosphor material emits light when struck by these high-energy electrons. The frequency and intensity of the light emitted depends on the type of phosphor material used and energy of the electrons. To produce a picture on the screen, these directed electron beams start at the top of the screen and scan rapidly from left to right along the row of phosphor dots. They return to the leftmost position one line down and scan again, and repeat this to cover the entire screen. The return of the beam direction to the leftmost position one line down is called *horizontal retrace* during which the electron flow is shut off. In performing this scanning or sweeping type motion, the electron guns are controlled by the video data stream coming into the monitor from the video card, which varies the intensity of the electron beam at each position on the screen. The instantaneous

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control of the intensity of the electron beam at each dot is what controls the color and brightness of each pixel on the screen. All these happens extremely quickly, and the entire screen is drawn in a fraction (say, 1/60th) of a second.

An image in raster scan display is basically composed of a set of dots and lines; lines are displayed by making those dots bright (with desired color) which lie as close as possible to the shortest path between the endpoints of a line.

7.3.1 Refresh Rate and Interlacing

When a dot of phosphor material is struck by the electron beam, it glows for a fraction of a second and then fades. As brightness of the dots begins to reduce, the screen-image becomes unstable and gradually fades out.

In order to maintain a stable image, the electron beam must sweep the entire surface of the screen and then return to redraw it a number of times per second. This process is called *refreshing* the screen. After scanning all the pixel-rows of the display surface, the electron beam reaches the rightmost position in the bottommost pixel line. The electron flow is then switched off and the vertical deflection mechanism steers the beam to the top left position to start another cycle of scanning. This diagonal movement of the beam direction across the display surface is known as *vertical retrace*. If the electron beam takes too long to return and redraw a pixel, the pixel will begin to fade; it will return to full brightness only when redrawn. Over the full surface of the screen, this becomes visible as a *flicker* in the image, which can be distracting and hard on the eyes.

In order to avoid flicker, the screen image must be redrawn sufficiently quickly that the eye cannot tell that refresh is going on. The *refresh rate* is the number of times per second that the screen is refreshed. It is measured in Hertz (Hz), the unit of frequency. The refresh rates are somewhat standardized; common values are 56, 60, 65, 70, 72, 75, 80, 85, 90, 95, 100, 110 and 120 Hz. Though higher refresh rates are preferred for better comfort in viewing the monitor, the maximum refresh rate possible depends on the resolution of the image. The maximum refresh rate that a higher resolution image can support is less than that supported by a lower resolution image, because the monitor has more number of pixels to cover with each sweep. Actually support for a given refresh rate requires two things: a video card capable of producing the video images that many times per second, and a monitor capable of handling and displaying that many signals per second.

Every monitor should include as part of its specification a list of resolutions it supports and the maximum refresh rate for each resolution. Many video cards now include setup utilities that are pre-programmed with information about different monitors. When you select a monitor, the video card automatically adjusts the resolutions and respective allowable refresh rates. Windows 95 and later versions extends this facility by supporting Plug and Play for monitors; you plug the monitor in and Windows will detect it, set the correct display type and choose the optimal refresh rate automatically.

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Some monitors use a technique called *interlacing* to cheat a bit and allow themselves to display at a higher resolution than is otherwise possible. Instead of refreshing every line of the screen, when in an interlaced mode the electron guns sweep alternate lines on each pass. In the first pass, odd-numbered lines are refreshed, and in the second pass, even-numbered lines are refreshed. This allows the refresh rate to be doubled because only half the screen is redrawn at a time. The usual refresh rate for interlaced operation is 87 Hz, which corresponds to 43.5 Hz of "real" refresh in half-screen interlacing.

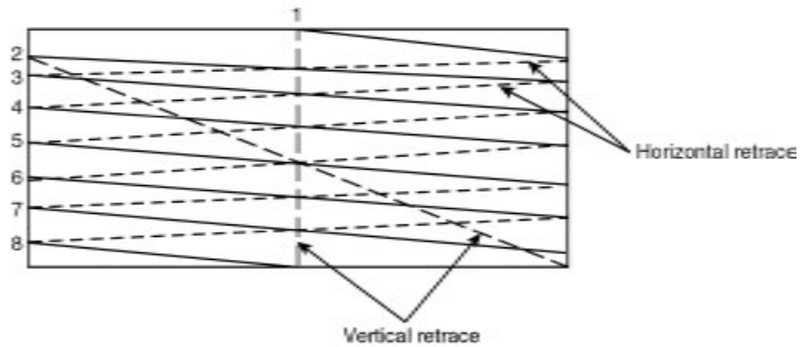

Fig. 7.1 *Schematic diagram of an interlaced raster scan*

In the above figure 7.1, the odd-numbered lines represents scanning one half of the screen and the even-numbered lines represents scanning of the other half. There are two separate sets of horizontal and vertical retrace.

7.3.2 CRT

A CRT is similar to a big vacuum glass bottle. It contains three electron guns that squirt out focused beam of electrons, deflection apparatus (magnetic or electrostatic), which deflects these beams both up and down and sidewise, and a phosphor-coated screen upon which these beams impinge. The vacuum is necessary to let those electron beams travel across the tube without running into air molecules that could absorb or scatter them.

The primary component in an electron gun is a *cathode* (negatively charged) encapsulated by a metal cylinder known as the *control grid*. A heating element inside the cathode causes the cathode to be heated up as current is passed, and as a result electrons "boil-off" from the hot cathode surface. These electrons are accelerated towards the CRT screen by a high positive voltage applied near the screen or by an *accelerating anode*. If allowed to continue uninterrupted, the naturally diverging electrons would simply flood the entire screen. The cloud of electrons is forced to converge to a small spot as it touches the CRT screen by a *focusing system* using an electrostatic or magnetic field. Just as an optical lens focuses a beam of light at a particular focal distance, a positively charged metal cylinder focuses the electron beam passing through it on the center of the CRT screen. A pair of magnetic *deflection coils* mounted outside the CRT envelope

deflects the concentrated electron beam to converge at different points on the screen in the process of scanning. Horizontal deflection is obtained by one pair of coils and vertical deflection by the other pair, and the deflection amount is controlled by adjusting the current passing through the coils. When the electron beam is deflected away from the center of the screen, the point of convergence tends to fall behind the screen resulting in blurred (defocused) display near the screen edges. In high-end display devices this problem is eliminated by a mechanism which dynamically adjusts the beam focus at different points on the screen.

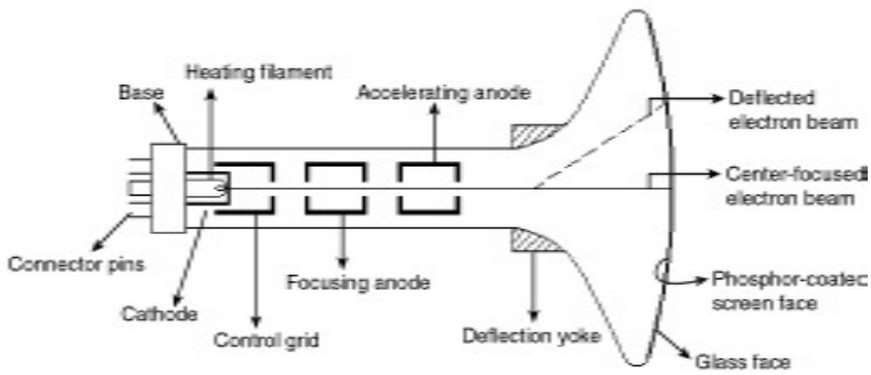

Fig. 7.2 *Schematic diagram of a raster scan CRT*

When the electron beam converges on to a point on the phosphor-coated face of the CRT screen, the phosphor dots absorb some of the kinetic energy from the electrons. This causes the electrons in the phosphor atoms to jump to higher energy orbits. After a short time these excited electrons drop back to their earlier stable state, releasing their extra energy as small quantum of light energy. As long as these excited electrons return back to their stable state phosphor continue to glow (*phosphorescence*) but gradually loses brightness. The time between the removal of excitation and the moment when phosphorescence has decayed to 10% of the initial brightness is termed as *persistence* of phosphor. The brightness of the light emitted by phosphor depends on the intensity with which the electron beam (number of electrons) strikes the phosphor. The intensity of the beam can be regulated by applying measured negative voltage at the control grid. Corresponding to a zero value in the frame buffer a high negative voltage is applied in the control grid, which in turn will shut off the electron beam by repelling the electrons and stopping them from coming out of the gun and hitting the screen. The corresponding points on the screen will remain black. Similarly a bright white spot can be created at a particular point by minimising the negative voltage at the control grid of the three electron guns when the respective electron beams are directed to that point by the deflection mechanism.

Apart from brightness the size of the illuminated spot created on the screen varies directly with the intensity of the electron beam. As the intensity or number of

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electrons in the beam increases, the beam diameter and spot size increases. Also the highly excited bright phosphor dots tends to spread the excitation to the neighbouring dot thereby further increasing the spot size. Therefore the total number of distinguishable spots (pixels) that can be created on the screen depends on the individual spot size. The lower the spot size, the higher the image resolution.

In a monochrome CRT there is only one electron gun, whereas in a color CRT there are three electron guns each controlling the display of red, green and blue light respectively. Unlike the screen of a monochrome CRT, which has a uniform coating of phosphor, the color CRT has three color-phosphor dots (dot triad) – red, green and blue – at each point on the screen surface. When struck by electron beam the red dot emits red light, the green dot emits green light and the blue dot emits blue light. Each triad is arranged in a triangular pattern, as are the three electron guns. The beam deflection arrangement allows all the three beams to be deflected at the same time to form a raster scan pattern. There are separate video streams for each RGB (red, green and blue) color component which drive the electron guns to create different intensities of RGB colors at each point on the screen. To ensure that the electron beam emitted from individual electron guns strikes only the correct phosphor dots (e.g., the electron gun for red color excites only the red phosphor dot), a *shadow mask* is used just before the phosphor screen. The mask is a fine metal sheet with a regular array of holes punched in it. The mask is so aligned that as the set of three beams sweeps across the shadow mask they converge and intersect at the holes and then hits the correct phosphor dot; the beams are prevented or masked from intersecting other two dots of the triad. Thus different intensities can be set for each dot in a triad and a small color spot is produced on the screen as a result.

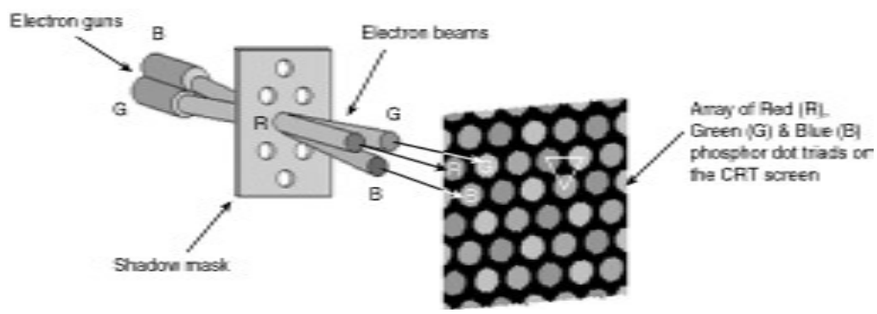

Fig. 7.3 *Electron beams passing through Shadow Mask*

An alternative way to accomplish the masking function is adopted by some CRTs. Instead of a shadow mask, they use an *aperture grill*. In this system the metal mesh is replaced by hundreds of fine metal strips that run vertically from the top of the screen to the bottom. In these CRTs, the electron guns are placed side-by-side (not in a triangular fashion).The gaps between the metal wires allow the three electron beams to illuminate the adjacent columns of colored phosphor which are arranged in alternating stripes of red, green and blue. This configuration allows the phosphor stripes to be placed closer together than conventional dot triads.

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The fine vertical wires block less of the electron beam than ordinary shadow masks resulting in brighter and sharper image. This design is most common in Sony's popular *Trinitron*. Trinitron monitors are curved only in the horizontal plane but are flat vertically.

For TV sets and monitors the diagonal dimension is stated as the size. As a portion at the edge of the picture tube is covered by the case, the actual viewable portion of the tube measures only 19 inches diagonally. For standard monitors the height is about three-fourth of the width. For a 19 inch monitor the image width will be 15 inches and the height will be 11 inches.

7.3.3 Bit Planes, Color Depth and Color Palette

The appearance and color of a pixel of an image is a result of intersection of three primary colors (red, green and blue) at different intensities. When the intensities of all three electron beams are set to the highest level (causing each dot of a triad to glow with maximum intensity), the result is a white pixel; when all are set to zero, the pixel is black. And for many different combinations of intermediate intensity levels, several million color pixels can be generated. For a mono monitor using a single electron gun, the phosphor material can glow with varied intensities depending on the intensity of the electron beam. As a result a pixel can be black (zero intensity) or white (maximum intensity) or have different shades of gray.

The number of discrete intensities that the video card is capable of generating for each primary color determines the number of different colors that can be displayed. The number of memory bits required to store color information (intensity values for all three primary color components) about a pixel is called *color depth* or *bit depth.* A minimum of one memory bit (color depth = 1) is required to store intensity value either 0 or 1 for every screen point or pixel. Corresponding to the intensity value 0 or 1, a pixel can be black or white respectively. So if there are n pixels in an image a total of n bits of memory used for storing intensity values will result in a pure black & white image. The block of memory which stores (or is mapped with) bilevel intensity values for each pixel of a full-screen pure black & white image is called a *bit plane* or *bitmap*.

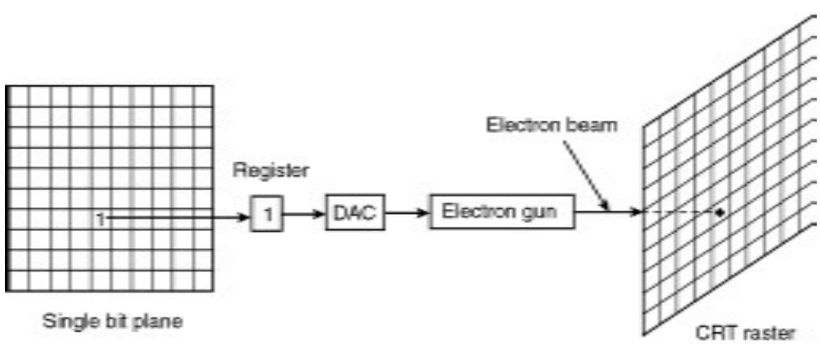

Fig. 7.4 *For bit depth =1, a pixel is illuminated (white) if intensity value 1 is stored in the corresponding memory address in the frame buffer*

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Color or gray levels can be achieved in the display using additional bit planes. First consider a single bit plane – a planar array of bits, with one bit for each screen pixel. This plane is replicated as many times as there are bits per pixel, placing each bit plane behind its predecessor. Hence the result for *n*-bits per pixel (color depth = *n*) is a collection of *n* bit planes that allows specifying any one of 2^n colors or gray shades at every pixel.

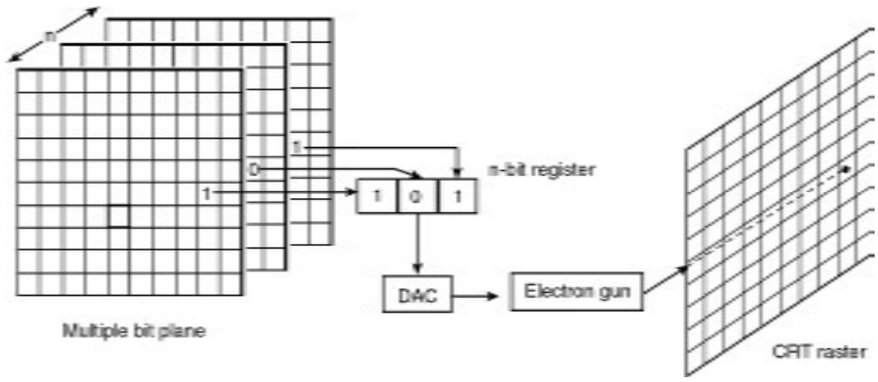

Fig. 7.5 *For bit depth = n , n number of bit planes are used; each bit plane contribute to the gray shade of a pixel*

The more the number of bits used per pixel, the finer the color detail of the image. However, increased color depths also require significantly more memory for storage, and also more data for the video card to process, which reduces the allowable refresh rate.

Table 7.2 *Common color depths used in PCs*

Color Depth	Number of Displayed Colors	Bytes of Storage Per Pixel	Common Name for Color Depth
4-Bit	16	0.5	Standard VGA
8-Bit	256	1.0	256-Color Mode
16-Bit	65,536	2.0	High Color
24-Bit	16,777,216	3.0	True Color

For *True color* three bytes of information are used, one for each of the red, blue and green signals that make a pixel. A byte can hold 256 different values and so 256 voltage settings are possible for each electron gun which means that each primary color can have 256 intensities, allowing over 16 million (256 × 256 × 256) color possibilities. This allows for a very realistic representation of the images, without necessitating any color compromise. In fact, 16 million colors is more than the human eye can discern. True color is a necessity for those doing high quality photo editing, graphical design, etc.

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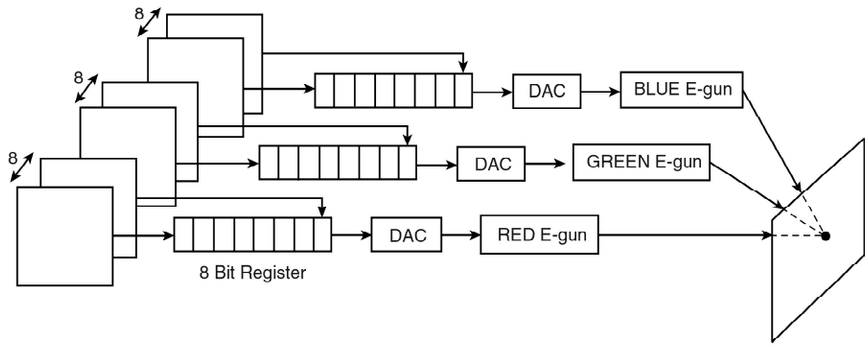

Fig. 7.6 *For bit depth =24 (true color display), 8 bit planes used for storing each primary color component of the color value of a pixel*

For *High color* two bytes of information are used to store the intensity values for all three colors. This is done by dividing 16 bits into 5 bits for blue, 5 bits for red and 6 bits for green. This means 32 (= 2^5) intensities for blue, 32 (= 2^5) for red, and 64 (= 2^6) for green. This reduced color precision results in a loss of visible image quality, but one cannot easily see the difference between true color and high color image. However high color is often used instead of true color because high color requires 33% (or 50% in some cases) less memory and also image generation is faster.

In *256-color mode* the PC uses only 8 bits; this means something like 2 bits for blue and 3 each for green and red . There are chances that most of the colors of a given picture are not available, and choosing between only 4 (= 2^2) or 8 (= 2^3) different values for each primary color would result in rather blocky or grainy look of the displayed image. A *palette* or *look-up table* is used here. A palette is a separate memory block (in addition to the 8 bit plane) created containing 256 different colors. The intensity values stored therein are not constrained within the range 0 to 3 for blue and 0 to7 each for green and red. Rather each color is defined using the standard 3-byte color definition that is used in true color. Thus the intensity values for each of the three primary color component can be anything between 0 and 255 in each of the table entries. Upon reading the bit planes, the resulting number instead of directly specifying the pixel color, is used as a pointer to the 3-byte color value entry in the look-up table. For example, if the color number read from the bit-planes is 10 for a given pixel, then the intensities of red, green and blue to be displayed for that pixel will be found in the 10th entry of the table. So the full range of true color can be accessed, but only 256 of the available 16 million colors can be used at a time.

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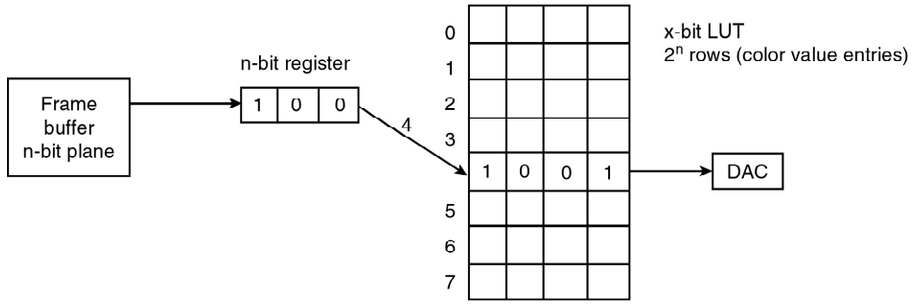

Fig. 7.7 *The n-bit register holds the row number of the look-up table; the particular row pointed contains the actual pixel intensity value which is a x-bit number (x>n)*

The palette is an excellent compromise at the cost of moderate increase in memory: it allows only 8 bits of the frame buffer to be used to specify each color in an image and allows the creator of the image to decide what the 256 colors in the image should be. Because the palette can be reloaded any time with different combination of 256 colors out of 16 million without changing the frame buffer values. Since virtually no image contain an even distribution of colors, this allows for more precision in an image by using more colors than would be possible by assigning each pixel a 2-bit value for blue and 3-bit value each for green and red. For example, an image of the sky with clouds (like the Windows 95 standard background) would have different shades of blue, white and gray, and virtually no red, green, yellow and the like.

256-color is the standard for much of computing, mainly because the higher-precision color modes require more resource (especially video memory) and are not supported by many PCs. Despite the ability to "hand pick" the 256 colors, this mode produces noticeably worse image quality than high color.

7.3.4 Frame Buffer and Output Circuitry

In the early days of PCs, the amount of information displayed was less. A screen of monochrome text, for example, needs only about 2 KB of memory space. Special parts of the upper memory area (UMA) were dedicated to hold this video data. As the need for video memory increased into the megabyte range, it made more sense to put the memory on the video card itself. In fact, to preserve existing PC design limitations, it was necessary (there simply is not any more space in the UMA to hold bigger screen images). The *frame buffer* is the video memory (RAM) that is used to hold or map the image displayed on the screen. The amount of memory required to hold the image depends primarily on the resolution of the screen image and also the color depth used per pixel. The formula to calculate how much video memory is required at a given resolution and bit depth is quite simple:

–Memory in MB = (X-resolution × Y-resolution × Bits-per-pixel)/(8 × 1024 × 1024)

Practically you need more memory than this formula compute. One major reason is that video cards are available only in certain memory configurations (in

terms of whole megabytes). For example you can't order a card with 1.7 MB of memory; you have to use a standard 2MB card available in the market. Another reason is that many video cards, especially high end accelerators and 3D cards, use memory for computation as well as for the frame buffer. Thus they need much more memory than is required strictly to hold the screen image.

Table 7.3 shows, in binary megabytes, the amount of memory required for the frame buffer for each common combination of screen resolution and color depth. The smallest industry standard video memory configuration required to support the combination is shown in parentheses.

Table 7.3 *Video Memory Configurations*

Resolution	4 Bits	8 Bits	16 Bits	24 Bits	32 Bits
320 × 200	0.03 (256 KB)	0.06 (256 KB)	0.12 (256 KB)	0.18 (256 KB)	--
640 × 480	0.15 (256 KB)	0.29 (512 KB)	0.59 (1 MB)	0.88 (1 MB)	1.17 (2 MB)
800 × 600	--	0.46 (512 KB)	0.92 (1 MB)	1.37 (2 MB)	1.83 (2 MB)
1024 × 768	--	0.75 (1 MB)	1.50 (2 MB)	2.25 (4 MB)	3.00 (4 MB)
1280 × 1024	--	1.25 (2 MB)	2.50 (4 MB)	3.75 (4 MB)	5.00 (6 MB)
1600 × 1200	--	1.83 (2 MB)	3.66 (4 MB)	5.49 (6 MB)	7.32 (8 MB)

Some motherboard designs integrate the video chipset into the motherboard itself and use a part of the system RAM for the frame buffer. This is called *unified memory architecture*. This is done for cost saving. The result is almost much lower video performance, because in order to use higher resolutions and refresh rates, the video memory needs to have much higher performance than the RAM normally used for the system. This is also the reason why video card memory is so expensive compared to regular system RAM.

In order to meet the increasing demand for faster and dedicated video memory at a comparable price, a technology introduced by Intel is fast becoming a new standard. It is called the *Accelerated Graphics Port* or *AGP*. The AGP allows the video processor access the system memory for graphics calculations, but keeps a dedicated video memory for the frame buffer. This is more efficient because the system memory can be shared dynamically between the system processor and the video processor, depending on the needs of the system. However it should be remembered that AGP is considered a port – a dedicated interface between the video chipset and the system processor.

The display adapter circuitry (on video card or motherboard) in a raster graphics system typically employs a special purpose processor called *Display Processor* or *Graphics Controller* or *Display Coprocessor* which is connected as an I/O peripheral to the CPU. Such processors assist the CPU in scan-converting[1] the output primitives (line, circle, arc etc.) into bitmaps in frame buffer and also perform raster operations of moving, copying and modifying pixels or block of pixels. The output circuitry also includes another specialised hardware called *Video Controller* which actually drives the CRT and produces the display on the screen.

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The monitor is connected to the display adapter circuitry through a cable with 15-pin connectors. Inside the cable are three analog signals carrying brightness information in parallel for the three color components of each pixel. The cable also contains two digital signal lines for vertical and horizontal drive signals and three digital signal lines which carry specific information about the monitor to the display adapter.

The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep its beam across the screen during raster scan. Memory reference addresses are generated in synchrony with the raster scan, and the contents of the memory are used to control the CRT beam intensity or color. Two registers (X register and Y register) are used to store the coordinates of the screen pixels. Assume that the y values of the adjacent scan lines increase by 1 in upward direction starting from 0 at the bottom of the screen to y_{max} at the top. And along each scan line the screen pixel positions or *x* values are incremented by 1 from 0 at the leftmost position to x_{max} at the rightmost position. The origin is at the lower left corner of the screen as in a standard Cartesian coordinate system. At the start of a refresh cycle, the X register is set to 0 and the Y register is set to y_{max}. This (x, y) address is translated into a memory address of frame buffer where the color value for this pixel position is stored. The controller retrieves this color value (a binary number) from the frame buffer, breaks it up into three parts and sends each part to a separate digital-to-analog converter (DAC)[2]. After conversion the DAC puts the proportional analog voltage signals on the three analog output wires going to the monitor. These voltages in turn controls the intensity of three electron beams that are focused at the (x,y) screen position by the horizontal and vertical drive signals.

This process is repeated for each pixel along the top scan line, each time incrementing the X register by 1. As pixels on the first scan line are generated the X register is incremented through x_{max}. Then the X register is reset to 0 and the Y register is decremented by 1 to access the next scan line. Pixels along this scan line are then processed and the procedure is repeated for each successive scan line until pixels on the last scan line ($y = 0$) are generated. For a display system employing a color look-up table, however, frame buffer value is not directly used to control the CRT beam intensity. It is used as an index to find the true pixel-color value from the look-up table. This look-up operation is done for each pixel on each display cycle.

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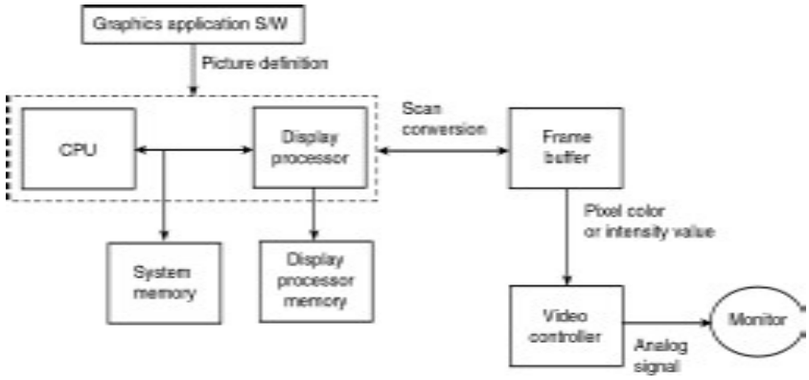

Fig. 7.8 *General architecture of a raster display system*

As the time available to display or refresh a single pixel in the screen is too less (in the order of a few nanoseconds), accessing the frame buffer every time for reading each pixel intensity value would consume more time than what is allowed. Therefore multiple adjacent pixel values are fetched to the frame buffer in a single access and stored in a register. After every allowable time gap (as dictated by the refresh rate and resolution) one pixel value is shifted out from the register to control the beam intensity for that pixel. The procedure is repeated with the next block of pixels and so on, thus the whole group of pixels will be processed.

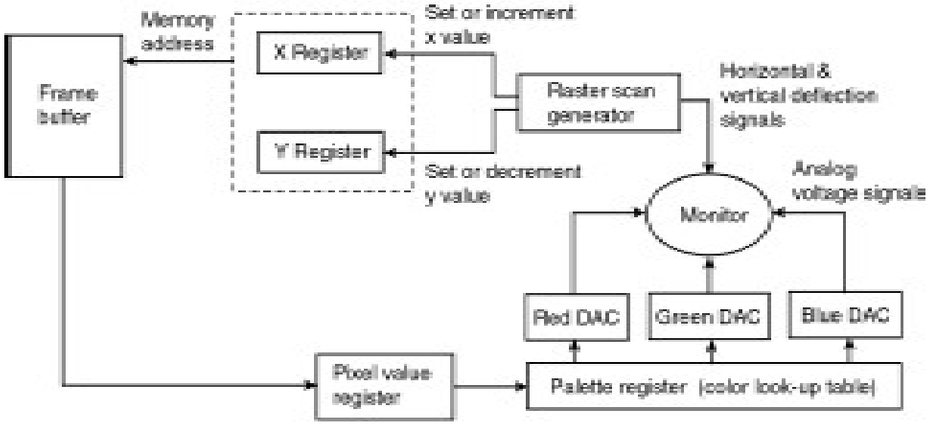

Fig. 7.9 *Logical operations of the video controller*

Check Your Progress

1. Define the term pixel.
2. Name the material with which internal surface of the monitor screen is coated.
3. What is a dot pitch?
4. Why is CRT used?
5. State the role of Accelerated Graphics Port or AGP.

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7.4 RANDOM SCAN DISPLAY

Basically there are two types of CRT's – Raster Scan type and Random Scan type. The main difference between the two is the technique with which the image is generated on the phosphor coated CRT screen. In raster scan method, the electron beam sweeps the entire screen in the same way you would write a full page text in a notebook, word by word, character by character, from left to right, and from top to bottom. Whereas in random scan technique, the electron beam is directed straightway to the particular point(s) of the screen where the image is to be produced. It generates the image by drawing a set of random straight lines much in the same way one might move a pencil over a piece of paper to draw an image – drawing strokes from one point to another, one line at a time. This is why this technique is also referred as *vector drawing* or *stroke writing* or *calligraphic display*.

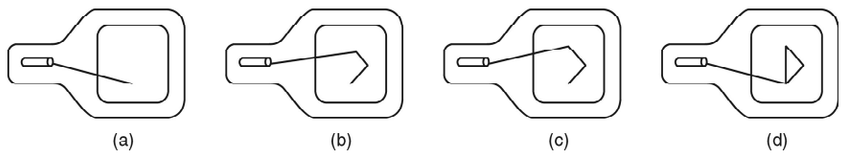

Fig. 7.10 *Drawing a triangle on a random scan display*

There are of course no bit planes containing mapped pixel values in vector system. Instead the display buffer memory stores a set of line drawing commands along with end point coordinates in a *display list* or *display program* created by a graphics package. The display processing unit (DPU) executes each command during every refresh cycle and feeds the *vector generator* with digital x, y and Dx, Dy values. The vector generator converts the digital signals into equivalent analog deflection voltages. This causes the electron beam to move to the start point or from the start point to the end point of a line or vector. Thus the beam sweep does not follow any fixed pattern; the direction is arbitrary as dictated by the display commands. When the beam focus must be moved from the end of one stroke to the beginning of the other, the beam intensity is set to 0.

Though the vector-drawn images lack in depth and real – like color precision, the random displays can work at higher resolutions than the raster displays. The images are sharp and have smooth edges unlike the jagged edges and lines on raster displays.

7.5 DIRECT VIEW STORAGE TUBE

Direct View Storage Tube (DVST) is rarely used today as part of a display system. However, DVST marks a significant technological change in the usual refresh type display. Both in the raster scan and random scan system the screen image is maintained (flicker free) by redrawing or refreshing the screen many times per

second by cycling through the picture data stored in the refresh buffer. In DVST there is no refresh buffer; the images are created by drawing vectors or line segments with a relatively slow-moving electron beam. The beam is designed not to draw directly on phosphor but on a fine wire mesh (called *storage mesh*) coated with dielectric and mounted just behind the screen. A pattern of positive charge is deposited on the grid, and this pattern is transferred to the phosphor coated screen by a continuous flood of electrons emanating from a separate flood gun.

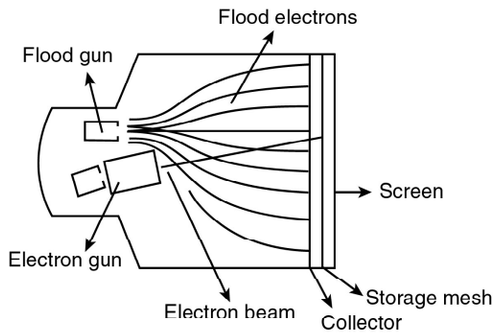

Fig. 7.11 *Schematic diagram of a DVST*

Just behind the storage mesh is a second grid, the *collector*, whose main purpose is to smooth out the flow of flood electrons. These electrons pass through the collector at low velocity and are attracted to the positively charged portions of the storage mesh but repelled by the rest. Electrons not repelled by the storage mesh pass right through it and strike the phosphor.

To increase the energy of these slow moving electron and thus create a bright picture, the screen is maintained at a high positive potential.

The storage tube retains the image generated until it is erased. Thus no refreshing is necessary, and the image is absolutely flicker free.

A major disadvantage of DVST in interactive computer graphics is its inability to selectively erase parts of an image from the screen. To erase a line segment from the displayed image, one has to first erase the complete image and then redraw it by omitting that line segment. However, the DVST supports a very high resolution which is good for displaying complex images.

7.6 DEVICE BASED CONTROLS

Input Devices

Various devices are available for data input to general purpose computer systems with graphic capabilities or sophisticated workstations designed for graphics applications. Among these devices are graphic tablets, light pens, joysticks, touch panels, data gloves, image scanner, trackballs, digitizer, voice systems and of course the common alpha-numeric keyboard and mouse. Presented below are the basic functional characteristics and application of these devices.

NOTES

Keyboard

Using a keyboard, a person can type a document, use keystroke shortcuts, access menus, play games and perform a variety of other tasks. Though keyboards can have different keys depending on the manufacturer, the operating system they're designed for, and whether they are attached to a desktop computer or part of a laptop still most keyboards have between 80 and 110 keys, including:

- Typing keys (letters A to Z, a to z, characters like < , ? + = etc.)
- A numeric keypad (numbers 0 to 9, characters like ! @ # ( ) etc.)
- Function keys (F1 to F12)
- Control keys (Ctrl, Alt, Del, Pg Up, Pg Dn, Home, End, Esc, , Fn, arrow keys etc.)

Function keys allow users to enter frequently used operations in a single keystroke and Control keys allow cursor and screen control. Displayed objects and menus can be selected using the Control keys.

A keyboard is a lot like a miniature computer. It has its own processor, circuitry (key matrix) and a ROM storing the character map. It uses a variety of switch technology.

Though the basic working technology is same there are design variations to make the keyboards easier and safer to use, versatile and elegant. Some of the non-traditional keyboards are Das keyboard, Virtual Laser keyboard, True-touch Roll-up keyboard, Ion Illuminated keyboard, Wireless keyboard etc.

Fig.7.12 *Microsoft Wireless Keyboard*

Mouse

A mouse is basically a handheld pointing device, designed to sit under one hand of the user and to detect movement relative to its two-dimensional supporting surface. It has become an inseparable part of a computer system just like keyboard. There is a cursor in the shape of an arrow or cross-hair always associated with a mouse. We reach out for mouse whenever we want to move the cursor or activate something or drag and drop or resize some object on display. Drawing or designing

figures and shapes using graphic application packages like AutoCAD, Photoshop, CorelDraw, Paint etc. is almost impossible without mouse.

NOTES

Fig. 7.13 *Microsoft's Two-button Wireless Mouse*

The mouse's 2D motion typically translates into the motion of a pointer on a display. In a *mechanical mouse* a ball–roller assembly is used; one roller used for detecting X direction motion and the other for detecting Y direction motion. An *optical mouse* uses LED and photodiodes (or optoelectronic sensors) to detect the movement of the underlying surface, rather than moving some of its parts as in a mechanical mouse. Modern *Laser mouse* uses a small laser instead of a LED.

A mouse may have one, two or three buttons on the top. Usually clicking the primary or leftmost button will select items or pick screen-points, and clicking the secondary or rightmost button will bring up a menu of alternative actions applicable to the selected item or specific to the context. Extra buttons or features are included in the mouse to add more control or dimensional input.

Trackball

A trackball is a pointing device consisting of a ball housed in a socket containing sensors to detect rotation of the ball about two axes—like an upside-down mouse with an exposed protruding ball. The user rolls the ball with their thumb, fingers, or the palm of their hand to move a cursor. A potentiometer captures the track ball orientation which is calibrated with the translation of the cursor on screen. Tracker balls are common on CAD workstations for ease of use and, before the advent of the touchpad, on portable computers, where there may be no desk space on which to use a mouse.

Fig. 7.14 *A Logitech*

NOTES

Joystick

A joystick is used as a personal computer peripheral or general control device consisting of a handheld stick that pivots about the base and steers the screen cursor around. Most joysticks are two-dimensional, having two axes of movement (similar to a mouse), but three-dimensional joysticks do exist. A joystick is generally configured so that moving the stick left or right signals movement along the X-axis, and moving it forward (up) or back (down) signals movement along the Y-axis. In joysticks that are configured for three-dimensional movement, twisting the stick left (counter-clockwise) or right (clockwise) signals movement along the Z-axis. In conventional joystick potentiometers or variable resistors are used to dynamically detect the location of the stick and springs are there to return the stick to center position as it is released.

Fig. 7.15 *The Flighterstick, a Modern Programmable USB Joystick*

In many joysticks optical sensors are used instead of analog potentiometer to read stick movement digitally. One of the biggest additions to the world of joysticks is force feedback technology. On using a force feedback (also called haptic feedback) joystick if you're shooting a machine gun in an action game, the stick would vibrate in your hands. Or if you crashed your plane in a flight simulator, the stick would push back suddenly which means the stick moves in conjunction with onscreen actions.

Joysticks are often used to control games, and usually have one or more push-buttons whose state can also be read by the computer. Most I/O interface cards for PCs have a joystick (game control) port. Joysticks were popular throughout the mid-1990s for playing games and flight-simulators, although their use has declined with promotion of the mouse and keyboard.

Digitizer and Graphics Tablet

A digitizer is locator device used for drawing, painting, or interactively selecting coordinate positions on an object. Graphics tablet is one such digitizer that consists of a flat surface upon which the user may draw an image using an attached stylus, a pen-like drawing apparatus. The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor.

NOTES

Fig. 7.16 *A Tablet with Hand Cursor*

The first graphics tablet resembling contemporary tablets was the RAND Tablet, also known as the Grafacon (for Graphic Converter) employed an orthogonal grid of wires under the surface of the pad. When pressure is applied to a point on the tablet using a stylus, the horizontal wire and vertical wire associated with the corresponding grid point meet each other, causing an electric current to flow into each of these wires. Since an electric current is only present in the two wires that meet, a unique coordinate for the stylus can be retrieved. The coordinate returned are tablet coordinates which are converted to user or screen coordinates by an imaging software. Even if it doesn't touch the tablet, proximity of the stylus to the tablet surface can also be sensed by virtue of a weak magnetic field projected approximately one inch from the tablet surface. It is important to note that, unlike the RAND Tablet, modern tablets do not require electronics in the stylus and any tool that provides an accurate "point" may be used with the pad. In some tablets multiple button hand-cursor is used instead of stylus. Graphics tablets are available in various sizes and price ranges A6-sized tablets being relatively inexpensive and A3-sized tablets being far more expensive.

Modern tablets usually connect to the computer via a USB interface. Because of their stylus-based interface and (in some cases) ability to detect pressure, tilt, and other attributes of the stylus and its interaction with the tablet, are widely used to create two-dimensional computer graphics. Free-hand sketches by an artist or drawing following an existing image on the tablet are useful while digitizing old engineering drawing, electrical circuits and maps and toposheets for GIS. Indeed, many graphics packages (e.g., Corel Painter, Inkscape, Photoshop, Pixel image editor, Studio Artist, The GIMP) are able to make use of the pressure (and, in some cases, stylus tilt) information generated by a tablet, by modifying attributes such as brush size, opacity, and color. Three dimensional graphics can also be created by a 3D digitizer that uses sonic or electromagnetic transmissions to record positions on a real object as the stylus moves over its surface.

Touch Panel

A touch panel is a display device that accepts user input by means of a touch sensitive screen. The input is given by touching displayed buttons or menus or

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icons with finger. In a typical *optical touch panel* LEDs are mounted in adjacent edges (one vertical and one horizontal). The opposite pair of adjacent edges contain light detectors. These detectors instantly identifies which two orthogonal light beams emitted by the LEDs are blocked by a finger or other pointing device and thereby records the x, y coordinates of the screen position touched for selection. However, because of its poor resolution the touch panel cannot be used for selecting very small graphic objects or accurate screen positions.

The other two type of touch panels are *electrical* (or *capacitive*) and *acoustical* touch panel. In an electrical touch panel two glass plates coated with appropriate conductive and resistive materials are placed face to face similar to capacitor plates. Touching a point on the display panel generates force which changes the gap between the plates. This in turn causes change in capacitance across the plates that is converted to coordinate values of the selected screen position. In acoustic type, similar to the light rays, sonic beams are generated from the horizontal and vertical edges of the screen. The sonic beam is obstructed or reflected back by putting a finger in the designed location on the screen. From the time of travel of the beams the location of the finger tip is determined.

Touch panels have gained wide acceptance in bank ATMs, video games and railway or tourist information system.

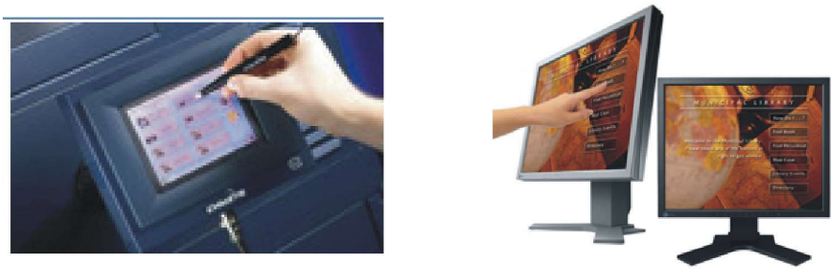

Fig. 7.17 *Touch Panels*

Light Pen

A Light Pen is a pointing device shaped like a pen and is connected to the computer. The tip of the light pen contains a light-sensitive element (photoelectric cell) which, when placed against the screen, detects the light from the screen enabling the computer to identify the location of the pen on the screen. It allows the user to point to displayed objects, or draw on the screen, in a similar way to a touch screen but with greater positional accuracy. A light pen can work with any CRT-based monitor, but not with LCD screens, projectors or other display devices.

The light pen actually works by sensing the sudden small change in brightness of a point on the screen when the electron gun refreshes that spot. By noting exactly where the scanning has reached at that moment, the x, y position of the pen can be resolved. The pen position is updated on every refresh of the screen.

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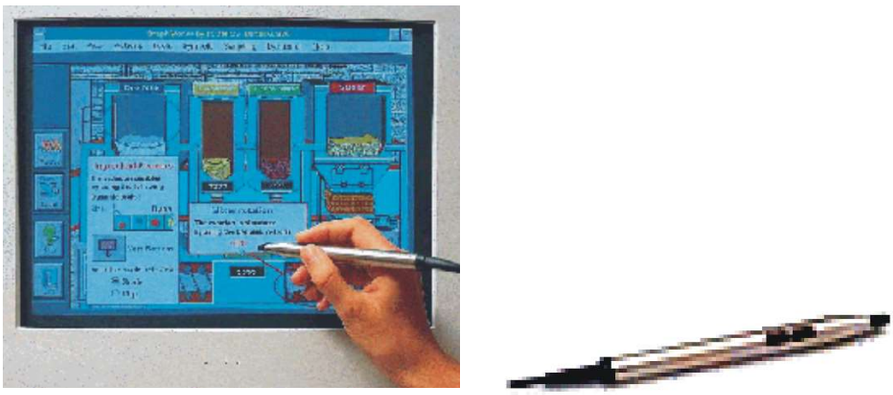


Fig. 7.18 *Light Pen*

Light pens are popularly used to digitize map or engineering drawing or signature or handwriting.

Data Glove

The *data glove* is an interface device that uses position tracking sensors and fiber optic strands running down each finger and connected to a compatible computer; the movement of the hand and fingers are displayed live on the computer monitor which in-turn allows the user to virtually touch an object displayed in the same monitor. With the object animated it would appear that the user (wearing the data glove) can pick up an object and do things with it just as he would do with a real object. In modern data glove devices, tactile sensors are used to provide the user with an additional feeling of touch or the amount of pressure or force the fingers or hands are exerting even though the user is not actually touching anything. Thus data glove is an agent to transport the user to virtual reality.

Fig. 7.19 *Data Glove*

NOTES

Voice-System

The voice-system or speech recognition system is a sophisticated input device that accepts voice or speech input from the user and transforms it to digital data that can be used to trigger graphic operations or enter data in specific fields. A dictionary is established for a particular operator (voice) by recording the frequency-patterns of the voice commands (words spoken) and corresponding functions to be performed. Later when a voice command is given by the same operator, the system searches for a frequency-pattern match in the dictionary and if found the corresponding action is triggered. If a different operator is to use the system then the dictionary has to be reestablished with the new operator's voice patterns.

Fig. 7.20 *Operator's Speech Recording*

Scanner

So far we have discussed some fundamental concept on how graphic images are generated and stored in some of the most common and widely used display systems. Let us briefly study a graphic device which directly copies images from a paper or photograph and converts it into the digital format for display, storage and graphic manipulations. It is the *Scanner.* Traditionally, design and publishing houses have been the prime users of scanners, but the phenomenal growth of Internet has made the scanner more popular among the web designers. Today scanners are becoming affordable tools to the graphic artists and photographers.

There are basically three types of scanners – *Drum*, *Flatbed* and *Sheetfed* scanners. Drum scanners are the high-end ones, whereas sheetfed scanners are the ordinary type. Flatbed scanners strike a balance between the two in quality as well as price. There are also *handheld scanners* or *bar-code readers* which are typically used to scan documents in strips of about 4 inches wide by holding the scanner in one hand and sliding it over the document.

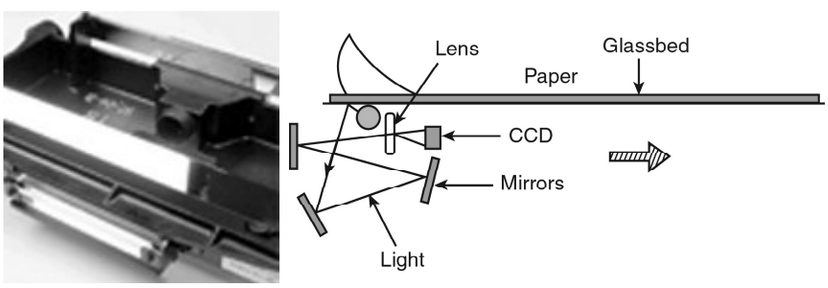
(a) Scanner *(b) Scan-surface in a scanner*

Fig. 7.21 *Flatbed scanner*

Flatbed Scanner

A flatbed scanner uses a light source, a lens, a charge coupled device (CCD) array and one or more analog-to-digital converters (ADCs) to collect optical information about the object to be scanned, and transform it to an image file. A CCD is a miniature photometer that measures incident light and converts that into an analog voltage.

When you place an object on the copyboard or glass surface (like a copier machine) and start scanning, the light source illuminates a thin horizontal strip of the object called a raster line. Thus when you scan an image, you scan one line at a time. During the exposure of each raster line, the scanner carriage (optical imaging elements, which is a network of lenses and mirrors) is mechanically moved over a short distance using a motor. The light reflected is captured by the CCD array. Each CCD converts the light to an analog voltage and indicates the gray level for one pixel. The analog voltage is then converted into a digital value by an ADC using 8, 10 or 12 bits per color.



Mirror and lens assembly in the scanner carriage *Scanning operation; the assembly of light, mirrors, lens and CCD moves over the length of the glassbed in the direction shown while scanning a paper*

Fig. 7.22

The CCD elements are all in a row, with one element for each pixel in a line. If you have 300 CCD elements per inch across the scanner, you can have a maximum potential optical resolution of 300 pixels per inch, also referred to as dots per inch (dpi).

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There are two methods by which the incident white light is sensed by the CCD. The first involves a rapidly rotating light filter that individually filters the red, green and blue components of the reflected light which are sensed by a single CCD device. Here the color filter is fabricated into the chip directly. In the second method, a prismatic beam splitter first splits the reflected white light and three CCDs are used to sense the red, green and blue light beams.

Another imaging array technology that has become popular in inexpensive flatbed scanners is *contact image sensor* (*CIS*). CIS replaces the CCD array, mirrors, filters, lamp and lens with rows of red, green and blue *light emitting diodes* (LEDs). The image sensor mechanism, consisting of 300 to 600 sensors spanning the width of the scan area, is placed very close to the glass plate that the document rests upon. When the image is scanned, the LEDs combine to provide white light. The illuminated image is then captured by the row of sensors. CIS scanners are cheaper, lighter and thinner, but do not provide the same level of quality and resolution found in most CCD scanners.

The output of a scanner is a bitmap image file, usually in a PCX or JPG format. If you scan a page of text, it may be saved as an image file which can not be edited in a word processing software. *Optical Character Recognition (OCR)* softwares are intelligent programs which can convert a scanned page of text into editable text either into a plain text file, a Word document or even an Excel spreadsheet which can be easily edited. OCR can also be used to scan and recognize printed, typewritten or even handwritten text. The OCR software requires a raster image as an input, which may be an existing image file or an image transferred from a scanner. OCR analyses the image to find blocks of image information that resemble possible text fields and creates an index of such areas. The software examines these areas, compares shape of each object with a database of words categorised by different fonts or typefaces and recognises individual text characters from the information.

7.7 OPERABLE CONTROLS

Operable controls are those that permit the entry, selection, changing, or editing of a particular value, or cause a command to be performed. Classes include buttons, text entry/read-only, selection, combination entry/selection, and other specialized controls.

Buttons

Description: A square or rectangular-shaped control with a label inside that indicates action to be accomplished. The label may consist of text, graphics, or both.

Purpose

To start actions.

To change properties.

To display a pop-up menu.

NOTES

Advantages

Always visible, reminding one of the choices available.

Convenient.

Can be logically organized in the work area.

Can provide meaningful descriptions of the actions that will be performed.

Larger size generally provides faster selection target.

Can possess 3-D appearance:

- Adds an aesthetically pleasing style to the screen.
- Provides visual feedback through button movement when activated.

  May permit use of keyboard equivalents and accelerators.

  Faster than using a two-step menu bar/pull-down sequence.

Disadvantages

- Consumes screen space.
- Size limits the number that may be displayed.
- Requires looking away from main working area to activate.
- Requires moving the pointer to select.

Proper Usage

Use for frequently used actions that are specific to a window.

- To cause something to happen immediately.
- To display another window.
- To display a menu of options.
- To set a mode or property value.

A button are of following three styles.

NOTES

Command Buttons

Command button guiding principles include the following.

Usage

For windows with a menu bar:

- Use to provide fast access to frequently used or critical commands.

For windows without a menu bar:

- Use to provide access to all necessary commands.

Structure

Provide a rectangular shape with the label inscribed within it.

Give the button a raised appearance.

Maintain consistency in style throughout an application.

Labels

Use standard button labels when available.

Provide meaningful descriptions of the actions that will be performed.

Use single-word labels whenever possible.

Use two-three words for clarity, if necessary.

Use mixed-case letters with the first letter of each significant label word capitalized.

Display Labels

- In the regular system font.
- In the same size font.

Do not number labels.

- Center the label within the button borders, leaving at least two pixels between the text and the button border.
- Provide consistency in button labelling across all screens.

Size

Provide as large a button as feasible.

Maintain consistent button heights and widths.

Exception: Buttons containing excessively long labels may be wider.

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Number

Restrict the number of buttons on a window to six or fewer.

Toolbars

Toolbars are compilations of commands, actions, or functions, usually graphical in structure but sometimes textual, grouped together for speedy access.

Toolbars may also be called *button bars*, *control bars,* or *access bars*. Specialized toolbars may also be referred to as *ribbons*, *toolboxes*, or *palettes*. Toolbars may also appear in palette windows.

Usage

To provide easy and fast access to most frequently used commands or options across multiple screens.

To invoke a sub application within an application.

To use in place of certain menu items.

Structure

Images: Provide buttons of equal size.

- Create a meaningful and unique icon.
- Design them using icon design guidelines.
- Center the image within the button.
- Give the button a raised appearance.

Ensure that toolbar images are discernible from Web page graphical images.

Text

Create a meaningful label, adhering to label guidelines for command buttons.

Create toolbar buttons of equal size, following the size guidelines.

Consistency: Use the same icon throughout an application and between applications.

Size

Button

24 (w) by 22 (h) pixels, including border.

32 (w) by 30 (h) pixels, including border.

Larger buttons can be used on high-resolution displays.

Label

16 (w) by 16 (h) pixels.

14 (w) by 24 (h) pixels.

Default: Provide the smaller size as the default size with a user option to change it.

Image: Center the image in the button.

NOTES

Organization

Order the buttons based on common and customary grouping schemes.

For buttons ordered left to right, place those for the most frequently used actions to the left.

For buttons ordered top to bottom, place those for the most frequently used actions at the top.

Keep related buttons grouped together.

Separate potentially destructive buttons from frequently chosen selections.

Permit user reconfiguration of button organization.

Location

Position main features and functions bar horizontally across top of window just below menu bar.

Position subtask and sub features bars along sides of window.

Permit the location of the bar to be changed by the user.

Permit display of the bar to be turned on or off by the user.

Also provide access through standard menus.

Active Items

Make only currently available toolbar items available.

Temporarily not available items may be displayed grayed out.

Customization

Permit toolbars to be turned off by the user.

Allow the customizing of toolbars.

Provide a default, however.

Keyboard Equivalents and Accelerators

Equivalents: Assign keyboard equivalents to facilitate keyboard selection. Maintain the same mnemonic on all identical buttons on all screens.

Accelerators: Assign a keyboard accelerator to facilitate keyboard selection.

Button Activation

Pointing: Highlight the button in some visually distinctive manner when the pointer is resting on it and the button is available for selection.

Activation: Call attention to the button in another visually distinctive manner when it has been activated or pressed.

Text Entry/Read-Only Controls

NOTES

A Text Entry/Read-Only control contains text that is exclusively entered or modified through the keyboard.

It may also contain entered text being presented for reading or display purposes only.

1. Text Entry/Read-Only Controls

For Entry Boxes

- Place a colon (:) immediately following the caption
- For single fields, caption can be located in front of upper left corner of the box
- For multiple fields, position the caption upper left of the box

For Read-Only Boxes

- If the data field is long or about the same length, center the caption above the displayed text box
- If the data is alphanumeric, short, or quite variable in length, left-justify the caption above the displayed
- If the data field is numeric and variable in length, right justify the caption above the displayed

2. Text Entry/Read-Only Controls (Fields)

- To visually indicate that it is an enterable field, present the box in a recessed manner
- Present read-only text boxes on the window background
- Break up long text boxes through incorporation of slashes (/), dashes (-), spaces, or common delimiters
- Call attention to text box data through a highlighting technique
- Gray-out temporarily unavailable text boxes

7.7.1 Selection Controls

- **Radio Buttons:** Radio boxes or buttons are used for selecting a single element from a group of list of elements or items. When the user selects a radio button, any button previously selected automatically gets deselected.
    i. Two part Radio Box control consists of the following:
        - Small circles, diamonds or rectangles.
        - Choice descriptions.

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ii. When an option is selected,
   - The option is highlighted.
   - Any existing choice is automatically un-highlighted and deselected.

iii. Purpose of radio buttons is to set one item from a small set of mutually exclusive options.

- **Check Boxes:** A checkbox is used for selecting many options at a time and some check boxes will be default checked. Each option acts as a switch and can be either "ON" or "OFF". When the user selects an option, then a mark, such as an "X" or "Check" appears within the square check box or the box is highlighted.

  i. A two-part control consists of a square box and choice or option description.

  ii. Each option acts as a switch and can be either "ON" or "OFF".
     - When an option is selected, a mark, such as an "X" or "Check" appears within the square box or the box is highlighted in some other manner.
     - Otherwise the square box is unselected or empty (OFF).

  iii. Each check box can be:
     - Switched ON or OFF independently.
     - Used alone or grouped in sets.

Combination Entry/Selection Controls

Spin Boxes

i. In the Spin box, single-line field is followed by two small vertically arranged buttons.
   - The top button has an arrow pointing up.
   - The bottom button has an arrow pointing down.

ii. Selection/Entry is done by,
   - Using the mouse to point at one of the directional buttons and clicking. Items will change by one unit or step with each click.
   - Keying a value directly into the field itself.

NOTES

iii. Objective of spin boxes is to make a selection by either scrolling through a small set of meaningful predefined choices or by typing text.

Combo Boxes

i. A Combo box is a single rectangular text box entry field, below which is a larger *rectangular* list box (resembling a drop-down list box) displaying a list of options.

ii. A text box authorisation is done by selection/options to be keyed within it.

iii. The larger box contains a list of mutually exclusive options from which one option can be selected for placement in the entry field. Selections are made by using a mouse to point and click.

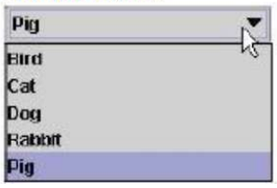
iv. As text is typed into the text box, the list scrolls to the nearest match.

v. When an item in the list box is selected, it is placed into the text box, replacing the existing content.

vi. Information keyed in the box may not inevitably have to match the list items.

vii. Objective of combo boxes is to document either typed entry in a text box or selection from a list of options in a permanently displayed list box attached to the text box.

Combo Boxes



7.7.2 Presentation Controls

Presentation controls are simply referred as informational, as these controls provide essential details about other screen elements or controls. For example, static text fields and group boxes and column headings.

Static Text Fields

i. Read-Only textual information.

ii. Objectives of static text fields are:

- To identify a control by displaying a control caption.
- To clarify a screen by providing instructional or prompting information.

NOTES

Group Boxes

i. A rectangular frame that surrounds a control or group of controls.
ii. An optional caption may be included in the frame's upper-left corner.
iii. Objectives of group boxes are:
   - To visually relate the elements of a control.
   - To visually relate a group of related controls.

Column Headings

A column heading control, also termed as a header control, is used for displaying a heading above the columns of text or numbers. Objectives is to categorise a column of information contained in a table.

Check Your Progress

6. How many types of CRT's are there?
7. List any one disadvantage of DVST in interactive computer graphics.
8. State the significance of a mouse in computers.
9. Define the term light pen.
10. What are operable controls?

7.8 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A pixel may be defined as the smallest size object or color spot that can be displayed and addressed on a monitor.
2. The internal surface of the monitor screen is coated with red, green and blue phosphor material that glows when struck by a stream of electrons.
3. The dot pitch is the distance between adjacent sets (triads) of red, green, and blue dots. This is also same as the shortest distance between any two dots of the same color, i.e., from red-to-red, or green-to-green like that.
4. The CRT works just like the picture tube of a television set. Its viewing surface is coated with a layer of arrayed phosphor dots.
5. Accelerated Graphics Port or AGP allows the video processor to access the system memory for graphics calculations but keeps a dedicated video memory for the frame buffer.
6. Basically, there are two types of CRT's – Raster Scan type and Random Scan type.
7. A major disadvantage of DVST in interactive computer graphics is its inability to selectively erase parts of an image from the screen.

NOTES

8. A mouse is basically a handheld pointing device, designed to sit under one hand of the user and to detect movement relative to its two-dimensional supporting surface.
9. A Light Pen is a pointing device shaped like a pen and is connected to the computer. The tip of the light pen contains a light-sensitive element (photoelectric cell) which, when placed against the screen, detects the light from the screen enabling the computer to identify the location of the pen on the screen.
10. Operable controls are those that permit the entry, selection, changing, or editing of a value, or cause a command to be performed.

7.9 SUMMARY

- The most prominent part in a personal computer is the display system that is responsible for graphic display.
- A pixel may be defined as the smallest size object or color spot that can be displayed and addressed on a monitor.
- There are two distinctly different terms, which are often confused. One is image resolution, and the other is screen resolution.
- The internal surface of the monitor screen is coated with red, green, and blue phosphor material that glows when struck by a stream of electrons.
- A higher resolution display allows you to see more information on your screen at a time and is particularly useful for operating systems, such as Windows.
- If the image resolution is more compared to the inherent resolution of the display device, then the displayed image quality gets reduced.
- This type of display basically employs a Cathode Ray Tube (CRT) or LCD Panel for display. The CRT works just like the picture tube of a television set.
- At the back of the CRT is a set of electron guns (cathodes) which produce controlled stream of electrons (electron beam).
- The frequency and intensity of the light emitted depends on the type of phosphor material used and energy of the electrons.
- When a dot of phosphor material is struck by the electron beam, it glows for a fraction of a second and then fades.
- To maintain a stable image, the electron beam must sweep the entire surface of the screen and then return to redraw it several times per second. This process is called refreshing the screen.
- The electron flow is then switched off and the vertical deflection mechanism steers the beam to the top left position to start another cycle of scanning.

NOTES

This diagonal movement of the beam direction across the display surface is known as vertical retrace.

- Every monitor should include as part of its specification a list of resolutions it supports and the maximum refresh rate for each resolution.
- Some monitors use a technique called interlacing to cheat a bit and allow themselves to display at a higher resolution than is otherwise possible.
- A CRT is like a big vacuum glass bottle. It contains three electron guns that squirt out focused beam of electrons, deflection apparatus which deflects these beams both up and down and sidewise, and a
- phosphor-coated screen upon which these beams impinge.
- The primary component in an electron gun is a cathode (negatively charged) encapsulated by a metal cylinder known as the control grid.
- Horizontal deflection is obtained by one pair of coils and vertical deflection by the other pair, and the deflection amount is controlled by adjusting the current passing through the coils.
- When the electron beam converges on to a point on the phosphor-coated face of the CRT screen, the phosphor dots absorb some of the kinetic energy from the electrons.
- In a monochrome CRT there is only one electron gun, whereas in a color CRT there are three electron guns each controlling the display of red, green, and blue light, respectively.
- The beam deflection arrangement allows all the three beams to be deflected at the same time to form a raster scan pattern.
- An alternative way to accomplish the masking function is adopted by some CRTs. Instead of a shadow mask, they use an aperture grill.
- The gaps between the metal wires allow the three electron beams to illuminate the adjacent columns of coloured phosphor which are arranged in alternating stripes of red, green, and blue.
- The number of discrete intensities that the video card can generate for each primary color determines the number of different colors that can be displayed.
- Some motherboard designs integrate the video chipset into the motherboard itself and use a part of the system RAM for the frame buffer. This is called unified memory architecture.
- The display adapter circuitry on video card or motherboard in a raster graphics system typically employs a special purpose processor called Display Processor or Graphics Controller or Display Coprocessor which is connected as an I/O peripheral to the CPU.
- The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep its beam across the screen during raster scan.

NOTES

- Memory reference addresses are generated in synchrony with the raster scan, and the contents of the memory are used to control the CRT beam intensity or color.
- The main difference between the two is the technique with which the image is generated on the phosphor coated CRT screen.
- In raster scan method, the electron beam sweeps the entire screen in the same way you would write a full-page text in a notebook, word by word, character by character, from left to right, and from top to bottom.
- Direct View Storage Tube (DVST) is rarely used today as part of a display system.
- To increase the energy of these slow-moving electron and thus create a bright picture, the screen is maintained at a high positive potential.
- The storage tube retains the image generated until it is erased. Thus, no refreshing is necessary, and the image is absolutely flicker free.
- A major disadvantage of DVST in interactive computer graphics is its inability to selectively erase parts of an image from the screen.
- Various devices are available for data input to general purpose computer systems with graphic capabilities or sophisticated workstations designed for graphics applications.
- Using a keyboard, a person can type a document, use keystroke shortcuts, access menus, play games and perform a variety of other tasks.
- Function keys allow users to enter frequently used operations in a single keystroke and Control keys allow cursor and screen control.
- A keyboard is a lot like a miniature computer. It has its own processor, circuitry (key matrix) and a ROM storing the character map. It uses a variety of switch technology.
- A mouse is basically a handheld pointing device, designed to sit under one hand of the user and to detect movement relative to its two-dimensional supporting surface.
- It has become an inseparable part of a computer system just like keyboard. There is a cursor in the shape of an arrow or crosshair always associated with a mouse.
- A trackball is a pointing device consisting of a ball housed in a socket containing sensors to detect rotation of the ball about two axes—like an upside-down mouse with an exposed protruding ball.
- The user rolls the ball with their thumb, fingers, or the palm of their hand to move a cursor.
- A joystick is used as a personal computer peripheral or general control device consisting of a handheld stick that pivots about the base and steers the screen cursor around.

NOTES

- A digitizer is locator device used for drawing, painting, or interactively selecting coordinate positions on an object.
- The first graphics tablet resembling contemporary tablets was the RAND Tablet, also known as the Grafacon (for Graphic Converter) employed an orthogonal grid of wires under the surface of the pad.
- A touch panel is a display device that accepts user input by means of a touch sensitive screen. The input is given by touching displayed buttons or menus or icons with finger.
- The other two type of touch panels are electrical (or capacitive) and acoustical touch panel.
- The voice-system or speech recognition system is a sophisticated input device that accepts voice or speech input from the user and transforms it to digital data that can be used to trigger graphic operations or enter data in specific fields.

7.10 KEY WORDS

- **Pixel:** It may be defined as the smallest size object or color spot that can be displayed and addressed on a monitor.
- **Dot pitch:** It is the distance between adjacent sets (triads) of red, green, and blue dots.
- **Aspect ratio:** The aspect ratio of the image is the ratio of the number of X pixels to the number of Y pixels.
- **CRT:** It contains three electron guns that squirt out focused beam of electrons, deflection apparatus which deflects these beams both up and down and sidewise, and a phosphor-coated screen upon which these beams impinge.
- **Function keys:** It allow users to enter frequently used operations in a single keystroke and control keys allow cursor and screen control.
- **Mouse:** It is basically a handheld pointing device, designed to sit under one hand of the user and to detect movement relative to its two-dimensional supporting surface.
- **Trackball:** It is a pointing device consisting of a ball housed in a socket containing sensors to detect rotation of the ball about two axes—like an upside-down mouse with an exposed protruding ball.
- **Joystick:** It is used as a personal computer peripheral or general control device consisting of a handheld stick that pivots about the base and steers the screen cursor around.
- **Digitizer:** It is locator device used for drawing, painting, or interactively selecting coordinate positions on an object.

NOTES

- **Touch panel**: It is a display device that accepts user input by means of a touch sensitive screen.
- **Light pen:** It is a pointing device shaped like a pen and is connected to the computer.
- **Radio buttons:** Radio boxes or buttons are used for selecting a single element from a group of lists of elements or items.
- **Check boxes:** A checkbox is used for selecting many options at a time and some check boxes will be default checked.
- **Presentation controls:** They are simply referred as informational, as these controls provide essential details about other screen elements or controls.

7.11 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. List few of the common types of display system available in the market.
2. Define the term Video Monitor or Video Display Unit (VDU).
3. Differentiate between image resolution and screen resolution.
4. What is the difference between image resolution and dot pitch?
5. Why is the refreshing screen process important for an image?
6. Define the term data gloves.
7. State the significance of flatbed scanners.
8. What is the purpose of buttons?
9. List any two advantages and disadvantages of buttons.
10. How are the command buttons useful?

Long-Answer Questions

1. Explain all the major display systems with the help of examples.
2. Elaborate on raster scan display with the help of suitable examples.
3. Describe bit planes, color depth and color palette in details giving relevant examples.
4. Discuss about the major drawbacks of Direct View Storage Tube (DVST) and why it is not used today?
5. Elaborate on device based controls and list all the various types of these controls giving examples.
6. Explain all the operable controls and discuss their significance giving appropriate examples.

7. What are selections controls? Name and give their advantages and disadvantages.

NOTES

7.12 FURTHER READINGS

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UNIT 8 DESIGN GOALS

NOTES

Structure

8.0 Introduction
8.1 Objectives
8.2 Screen and Web Page
8.2.1 Measurements of Performance
8.2.2 Web Page
8.3 Organising Screen Elements
8.3.1 Features of a Screen
8.4 Screen Navigation and Flow
8.5 Visually Pleasing Composition
8.6 Answers to Check Your Progress Questions
8.7 Summary
8.8 Key Words
8.9 Self Assessment Questions and Exercises
8.10 Further Readings

8.0 INTRODUCTION

A computer screen is an output device that displays information in pictorial form. A monitor usually comprises the visual display, circuitry, casing, and power supply. The display device in modern monitors is typically a thin film Transistor Liquid Crystal Display (TFT-LCD) with LED backlighting having replaced Cold-Cathode Fluorescent Lamp (CCFL) backlighting. Previous monitors used a Cathode Ray Tube (CRT), and some Plasma (also called Gas-Plasma) displays. Originally, computer monitors were used for data processing while television sets were used for entertainment.

Modern computer monitors are easily interchangeable with conventional television sets and vice versa. However, as computer monitors do not necessarily include integrated speakers nor TV tuners, (such as digital television adapters), it may not be possible to use a computer monitor as a TV set without external components.

A Web page (or Webpage) is a hypertext document provided by a Website and displayed to a user in a Web browser. A Website typically consists of many web pages linked together in a coherent fashion. The name 'Web page' is a metaphor of paper pages bound together into a book.

In this unit, you will study about the purpose of screens and Web pages, organising screen elements, features of a screen, screen navigation and flow, visually pleasing composition of screen and various components of screen.

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8.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of screens
- Interpret the components of a screen
- Discuss the various features of a screen
- Understand the importance of screen navigation and flow
- Learn about the concept of organising screen elements

8.2 SCREEN AND WEB PAGE

A computer screen is an output device that displays information in pictorial form. A monitor usually comprises the visual display, circuitry, casing, and power supply. The display device in modern monitors is typically a Thin Film Transistor Liquid Crystal Display (TFT-LCD) with LED or Light- Emitting Diode backlighting having replaced Cold-Cathode Fluorescent Lamp (CCFL) backlighting. Previous monitors used a Cathode Ray Tube (CRT) and some Plasma also called Gas-Plasma displays. Monitors are connected to the computer via VGA or Video Graphics Array, Digital Visual Interface (DVI), HDMI, DisplayPort, USB-C, Low-Voltage Differential Signaling (LVDS) or other proprietary connectors and signals.

Originally, computer monitors were used for data processing while television sets were used for entertainment. From the 1980s onwards, computers and their monitors have been used for both data processing and entertainment, while televisions have implemented some computer functionality. The common aspect ratio of televisions, and computer monitors, has changed from 4:3 to 16:10, to 16:9. Modern computer monitors are easily interchangeable with conventional television sets and vice versa. However, as computer monitors do not necessarily include integrated speakers nor TV tuners (,such as digital television adapters), it may not be possible to use a computer monitor as a TV set without external components.

Multiple technologies have been used for computer monitors. Until the 21st century most used cathode ray tubes but they have largely been superseded by LCD monitors.

1. Cathode Ray Tube

The first computer monitors used were Cathode Ray Tubes (CRTs). Prior to the advent of home computers in the late 1970s, it was common for a Video Display Terminal (VDT) using a CRT to be physically integrated with a keyboard and other components of the system in a single large chassis. The display was monochrome and far less sharp and detailed than on a modern flat-panel monitor, necessitating the use of relatively large text and severely limiting the amount

of information that could be displayed at one time. High-resolution CRT displays were developed for the specialized military, industrial and scientific applications but they were far too costly for general use.

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2. Liquid Crystal Display

There are multiple technologies that have been used to implement Liquid Crystal Displays (LCD). Throughout the 1990s, the primary use of LCD technology as computer monitors was in laptops where the lower power consumption, lighter weight, and smaller physical size of LCDs justified the higher price versus a CRT. Commonly, the same laptop would be offered with an assortment of display options at increasing price points: (active or passive) monochrome, passive color, or active matrix color. As volume and manufacturing capability have improved, the monochrome and passive color technologies were dropped from most product lines.

3. Organic Light-Emitting Diode

Organic Light-Emitting Diode (OLED) monitors provide higher contrast, better color reproduction and viewing angles than LCDs but they require more power when displaying documents with white or bright backgrounds and have a severe problem known as burn-in, just like CRTs. They are less common than LCD monitors and are often more expensive.

8.2.1 Measurements of Performance

The performance of a monitor is measured by the following parameters:

- Luminance is measured in candelas per square meter (cd/m^2, also called a *nit*).
- Color depth is measured in bits per primary color or bits for all colors. Those with 10 bpc (bits per channel) or more can display more shades of color (approximately 1 billion shades) than traditional 8 bpc monitors (approximately 16.8 million shades or colors), and can do so more precisely without having to resort to dithering.
- Gamut is measured as coordinates in the CIE 1931 color space. The names sRGB or Adobe RGB are shorthand notations.
- Aspect ratio is the ratio of the horizontal length to the vertical length. Monitors usually have the aspect ratio 4:3, 5:4, 16:10 or 16:9.
- Viewable image size is usually measured diagonally, but the actual widths and heights are more informative since they are not affected by the aspect ratio in the same way. For CRTs, the viewable size is typically 1 in (25 mm) smaller than the tube itself.
- Display resolution is the number of distinct pixels in each dimension that can be displayed. For a given display size, maximum resolution is limited by dot pitch.

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- Dot pitch or pixel pitch represents the size of the primary elements of the display. In CRTs, dot pitch is defined as the distance between sub-pixels of the same color. In LCD or Liquid Crystal Display it is the distance between the centre of two adjacent pixels. Dot pitch is the reciprocal of pixel density.
- Pixel density is a measure of how densely packed the pixels on a display are. In LCDs, pixel density is the number of pixels in one linear unit along the display, typically measured in pixels per inch (px/in or ppi).
- Refresh rate is (in CRTs) the number of times in a second that the display is illuminated (the number of times a second a raster scan is completed). In LCDs it is the number of times the image can be changed per second, expressed in hertz (Hz). Maximum refresh rate is limited by response time. Determines the maximum number of Frames Per Second (FPS) a monitor can show.
- Response time is the time a pixel in a monitor takes to change between two shades. The shades depend on the test procedure, which differs between manufacturers. In general, lower numbers mean faster transitions and therefore fewer visible image artifacts, such as ghosting.
- Input latency is the time it takes for a monitor to display an image after receiving it, typically measured in milliseconds (ms).
- Contrast ratio is the ratio of the luminosity of the brightest color (white) to that of the darkest color (black) that the monitor can produce simultaneously.
- Power consumption is measured in watts.
- Color accuracy is measured in ΔE (delta-E); the lower the ΔE, the more accurate the color representation. A ΔE of below 1 is imperceptible to the human eye. A ΔE of 2–4 is considered good and requires a sensitive eye to spot the difference.
- Viewing angle is the maximum angle at which images on the monitor can be viewed, without excessive degradation to the image. It is measured in degrees horizontally and vertically.
- Radius of curvature, for curved monitors, is the radius that a circle would have if it had the same curvature as the display. This value is typically given in millimetres but expressed with the letter 'R' instead of a unit (for example, a display with "3800R curvature" has a 3800 mm radius of curvature.

8.2.2 Web Page

A Web page is a hypertext document provided by a Website and displayed to a user in a Web browser. A Website typically consists of many Web pages linked together in a coherent fashion. The name 'Web page' is a metaphor of paper pages bound together into a book. The core element of a Web page is one or more text files written in the Hypertext Markup Language (HTML). Many Web pages also make use of JavaScript code for dynamic behavior and Cascading Style Sheets (CSS) code for presentation semantics. Web Assembly executables

can also be used for portions of page behavior. Images, videos, and other multimedia files are often embedded in Web pages.

Each Web page is identified by a distinct Uniform Resource Locator (URL). When the user inputs a URL into their browser, that page's elements are downloaded from Web servers. The browser then transforms all the elements into an interactive visual representation on the user's device. If the user clicks or taps a link to another page, the browser repeats this process to display the new page, which could be part of the current Website or a different one. From the perspective of server-side Website deployment, there are two types of Web pages: static and dynamic. Static pages are retrieved from the Web server's file system without any modification, while dynamic pages must be created by the server on the fly, typically reading from a database to fill out a template, before being sent to the user's browser.

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8.3 ORGANISING SCREEN ELEMENTS

The screen components must be organised logically, meaningfully, and sensibly for the user to easily maintain the information on the screen in his or her short-term memory. One way to do this is to arrange screen items in a prioritized order based on the user's preferences, specifications, and goals. Users can quickly locate the information they need thanks to well-organized displays quickly.

Organized screen covers basic principles as mentioned below:

1. It helps in orderly, clean, and clutter-free appearance. Such screen indication of what is being shown and what should be done with it and display the expected information.
2. It helps in indicating the screen is related to what which includes options, headings, captions, data, and so forth. Use of simple english helps in finding out what users look for. On the other hand, a clear indication of when an action can make a permanent change in the data or system.

8.3.1 Features of a Screen

Screen users look for:

- Identifies a task to be performed or need to be fulfilled.
- Decides how the task will be completed or need fulfilled.
- Manipulates the computers controls.
- Gathers necessary data.
- Form's judgments resulting in decisions relevant to task.

Screen design goals:

Considering the users requirements interface designer designs the screen. The designers try to fulfil all the specifications and expectation of the end users.

NOTES

The design goals are mentioned below:

- Reduce visual work.
- Reduce intellectual work.
- Reduce memory work.
- Reduce mentor work.
- Eliminate burdens or instructions.
- Reduce visual work.
- Reduce intellectual work.
- Reduce memory work.
- Reduce mentor work.
- Eliminate burdens or instructions.

Common ordering schemes include:

- Conventional
- Sequence of use
- Frequency of use
- Function or category
- Importance and
- General to specific.

8.4 SCREEN NAVIGATION AND FLOW

Every consumer expects the screen's navigation and flow to be clear and straightforward. By grouping and aligning screen controls and using line orders to direct the eye, navigation can be made evident.

Table 8.1 *Techniques/Arrangement/Orientation*

S. No	Techniques/Arrangement/Orientation
1	Most important & Most frequently used elements or controls placed at the top left.
2	Grouping of elements observable on the screen.
3	Line borders for groups.
4	Identifiable difference among elements that a critical, important, secondary, peripheral.
5	Command buttons placed at the bottom within a group.
6	Eye movement from dark areas to light areas of the Screen.
7	Eye movement from big objects to little objects
8	Eye movement from unusual shapes to common shapes.
9	Eye movement from highly saturated colors to unsaturated colors.

NOTES

Working with a screen should require less eye and manual control movements thanks to the Screen elements arrangement. In the study, the top-to-bottom presentation of knowledge outperformed all other types of presentations. Following points should be considered:

- Provide an ordering of screen information and elements that:
  - *Rhythmic guiding a person's eye through display.*
  - *Encourages natural movement sequences.*
  - *Minimizes pointer and eye movement distances.*
- Locate the most important and most frequently used elements or controls at top left.
- Maintain top to bottom, left to right flow.
- Assist in navigation through a screen by
  - *Aligning elements*
  - *Grouping elements*
  - *Use of line borders*
- Through focus and emphasis, sequentially, direct attention to items that are Critical
  - *Important*
  - *Secondary*
  - *Peripheral*
- Tab through window in logical order of displayed information.
- Locate command button at the end of the tabbing order sequence,
- When groups of related information must be broken and displayed on separate screens, provide breaks at logical or natural points in the information flow.
- In establishing eye movement through a screen, also consider that the eye trends to move sequentially, for example –
  - *From dark areas to light areas*
  - *From big objects to little objects*
  - *From unusual shapes to common shapes*
- Most product style guides recommend a left to right orientation.
- Our earliest display screens reflected this left to right entry orientation.
- Top to bottom orientation is also recommended for presenting displays of read only information that must be scanned.

NOTES

8.5 VISUALLY PLEASING COMPOSITION

Visually pleasing composition refers to the contrast between screen elements, create groupings. E.g., birth date grouping in a form, Align screen elements properly. E.g., screen elements on Web page. Screen based elements are textbox, radio buttons, checkboxes, provide 3D representations, etc.

Users are influenced by the symmetrical balance and weight of the titles, graphics, text, when scanning the interfaces initially. Visually pleasing composition draws user's attention inherently and makes positive impact on the user's mind. The visual techniques like balance, symmetry, regularity, predictability, sequentially, economy, unity and grouping will augment visual pleasing composition of user screen.

There are various elements involved in composition of visually pleasing:

➢ balance ➢ Symmetry ➢ Regularity ➢ Predictability ➢ Sequentiality	➢ Economy ➢ Unity ➢ Proportion ➢ Simplicity ➢ Groupings.

1. Balance versus Instable Design

Balance can be achieved by providing an equal weight of screen elements, left and right, top and bottom. On a screen, balance is achieved by centering the display, keeping equal weighting of components on both sides of the horizontal and vertical axes, and centering headlines and pictures. Instability is the opposite of equilibrium.

Instability in screen reduces the use of application so there are very high chances the organization may lose the users in future.

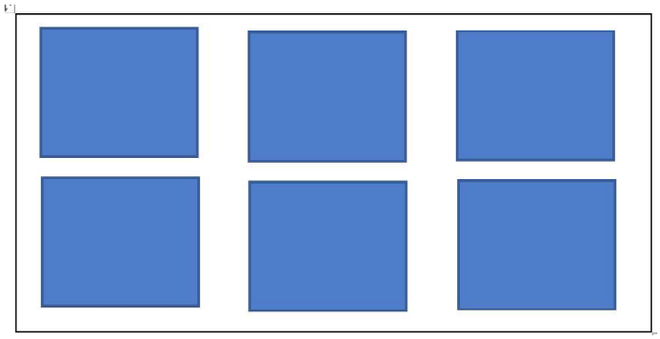

Fig. 8.1 *Balance Design*

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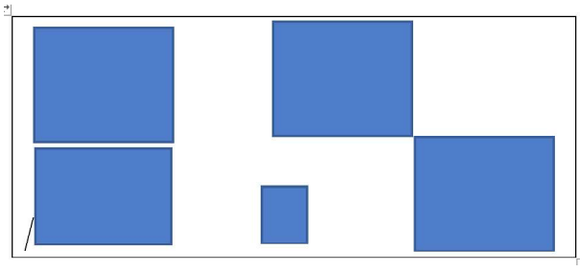

Fig. 8.2 *Instable Design*

2. Symmetry versus Asymmetry Design:

The opposite of symmetry is asymmetry. The symmetry brings compactness and symmetry lacks compactness in the user interface. Symmetry is axial duplication, which means that a unit on one side of the centreline is precisely duplicated on the other.

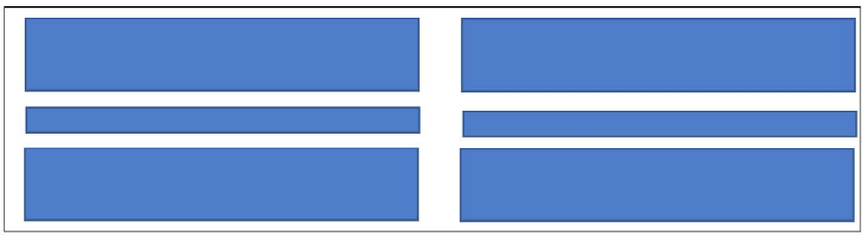

Fig. 8.3 *Symmetry Design*

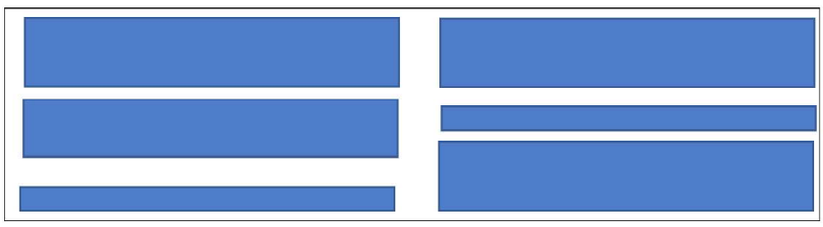

Fig.8.4 *Asymmetry Design*

3. Regularity versus Irregularity in Design

Regularity as a uniformity of elements based on some principle or plan. And it can be achieved by establishing standard, consistently spaced horizontal and vertical alignment points. Regularity can also be placed into the screen by using elements or controls of similar size, shape, color and spacing.

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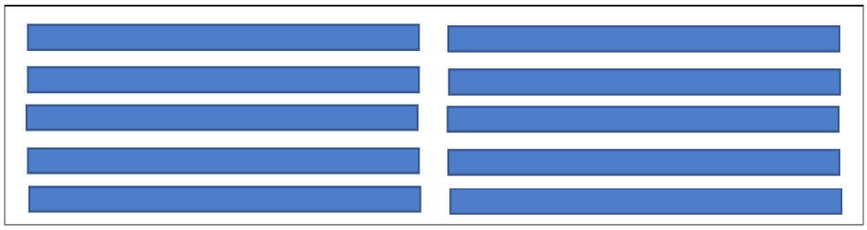

Fig.8.5 *Regular Design*

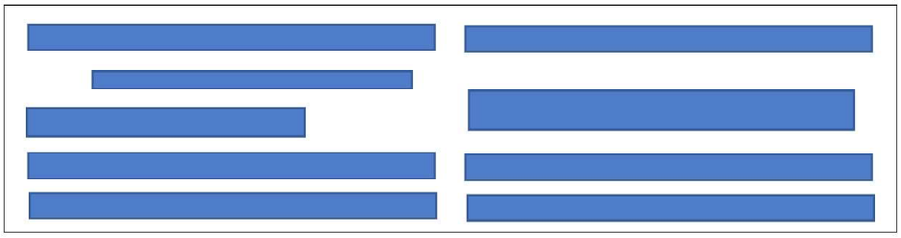

Fig. 8.6 *Irregular Design*

4. Predictability versus Spontaneous Design

Predictability denotes a well-established order or strategy. When a user looks at one screen, he or she can predict how another will appear. Also, viewing a part of screen, the user could easily predict how the rest of the screen looks like.

Spontaneity is the opposite of predictability, characterized by a lack of planning or pattern for the components displayed on the user interface.

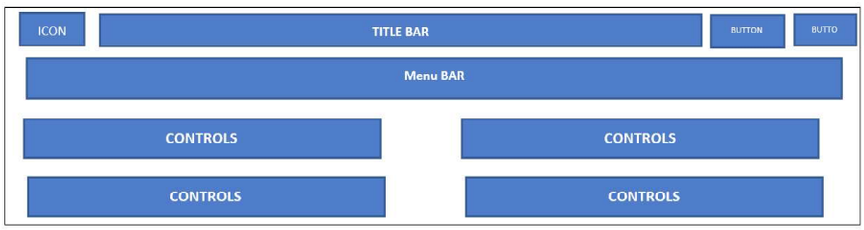

Fig. 8.7 *Predictability Design*

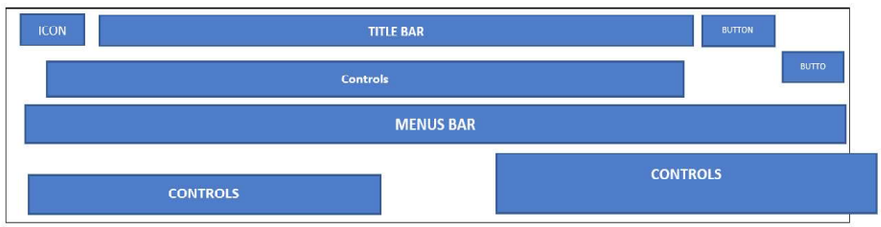

Fig. 8.8 *Spontaneous Design*

NOTES

5. Sequentially versus Randomness in Design

Sequentially is a plan of presentation to guide the eye through the screen in a logical, rhythmic order, with the most important information significantly placed. The opposite of sequentially is randomness which is highly undesirable to present to the user.

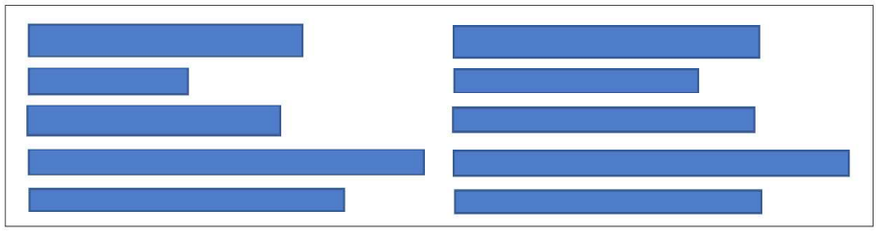

Fig. 8.9 *Sequential Design*

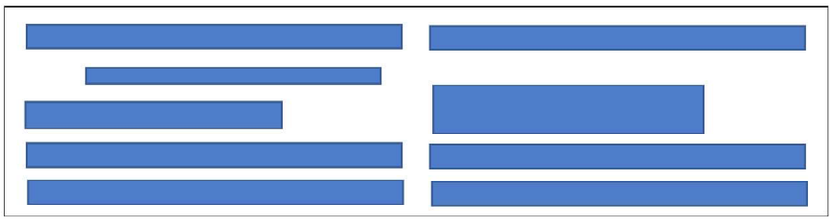

Fig.8.10 *Random Design*

6. Economy versus Literacy in Design

The UI designer has a lot of options when it comes to showing elements on the screen. But the usage of many different choices will degrade the users' visual appeal.

The efficient and careful use of display elements to deliver the idea through as simply as possible is referred to as economy. The opposite is intricacy, the use of many elements just because they exist.

7. Unity versus Fragmentation in Design

Unity is coherence, a totality of elements that is visually all one piece .When the elements of the screen are scattered in different directions, the visual appeal of the interface decreases, and the user becomes less compelled to use it. Elements appear to belong together when they are united.

Fragmentation is the opposite of Unity, with each piece having its own character. Similar sizes, shapes, colors, promote unity, as does white space and borders at the display boundaries.

Characteristics of visually pleasing composition:

- User Guidance
- Helpful for User with disabilities diversity.

NOTES

- Help in development of Simple user interface.
- Recoverability
- Flexibility
- Consistency
- Efficiency
- Responsiveness

User Guidance

The Meaningful feedback and help should be provided to the users by providing Help documentation or On-line manuals. The system must be useful in assisting in the faster and more efficient achievement of needed objectives.

Helpful for User with Disabilities Diversity

Application developed under consideration of should also consider of visually pleasing composition is always helpful for the disabled people . specially people with visual and hearing disabilities. E.g., some users have seeing difficulties, so larger text should be available.

Help in development of Simple User Interface

The interface of such an application should be as basic as possible, with the most common and necessary functions shown first, followed by the less often used ones. The easy personalization of UI is promoted and supported by an aesthetically beautiful design. Also, encouraging users to grasp the system leads to increased user satisfaction.

Recoverability

Each application or Website need to recover from errors. Application should help user in recognizing and recovering from errors by providing proper messages and actions to be taken to recover from the error E.g., incorrect debit card number enter error. Ensure that the user's work is never lost due to a technical error or hardware and software issues.

Flexibility

The user should be able to log in and log out without putting any extra effort. These options should be visible to the user on standard position. Not just Provide for flexible interaction, same action through keyboard commands, mouse movements or voice recognition.

The user should be able to tell where he came from and what options he has for moving on to a new activity. Allow the user to concentrate on their task without having to worry about the interface's technological aspects. The inner workings of the system should be hidden from the user.

Consistency

Application should have an appropriate level of consistency, that is all pages or screens should have same look and feel. Visually pleasing composition pay attention

to the position of standard elements, menus and control statements E.g., CTRL+C, CTRL+V. Because these shortcuts should be consistent across the system.

Efficiency

Application should be efficient enough to have minimize eye and hand movements. Not just movement rather navigation path should also be short. Another consideration is given to the eye movement throughout the screen. A screen should have a sequential movement.

Responsiveness

Now user is accessing applications and Website from different devices. Device may be a standalone machine, laptop, mobile or tablet. A responsive application is comparable to all devices and platforms. While in earlier days there were many Websites which were not compatible to mobile or were not giving the same look and feel as standalone machine.

NOTES

Check Your Progress

1. State the significance of Organic Light-Emitting Diode (OLED) monitors.
2. Differentiate between a Website and a Web page.
3. List the basic principles organized screen covers.
4. Name any two screen goals.
5. What is a visually pleasing composition of a screen?
6. What is the difference between symmetry is asymmetry?
7. Define the term predictability.

8.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Organic Light-Emitting Diode (OLED) monitors provide higher contrast, better color reproduction and viewing angles than LCDs but they require more power when displaying documents with white or bright backgrounds and have a severe problem known as burn-in, just like CRTs. They are less common than LCD monitors and are often more expensive.
2. A Web page (or Web page) is a hypertext document provided by a Website and displayed to a user in a Web browser. A Website typically consists of many Web pages linked together in a coherent fashion.
3. Organized screen covers basic principles as mentioned below:
   - It helps in orderly, clean, and clutter-free appearance. Such screen indication of what is being shown and what should be done with it and display the expected information.

NOTES

- It helps in indicating the screen is related to what which includes options, headings, captions, data, and so forth. Use of simple English helps in finding out what users look for. On the other hand, a clear indication of when an action can make a permanent change in the data or system.

4. The design goals are mentioned below:
   - Reduce visual work.
   - Reduce intellectual work.
5. Visually pleasing composition refers to the contrast between screen elements, create groupings.
6. The opposite of symmetry is asymmetry. The symmetry brings compactness and symmetry lacks compactness in the user interface. Symmetry is axial duplication, which means that a unit on one side of the centreline is precisely duplicated on the other.
7. Predictability denotes a well-established order or strategy. When a user looks at one screen, he or she can predict how another will appear. Also, viewing a part of screen, the user could easily predict how the rest of the screen looks like.

8.7 SUMMARY

- A computer screen is an output device that displays information in pictorial form.
- A monitor usually comprises the visual display, circuitry, casing, and power supply.
- The display device in modern monitors is typically a Thin Film Transistor Liquid Crystal Display (TFT-LCD) with Light-Emitting Diode LED backlighting having replaced Cold-Cathode Fluorescent Lamp (CCFL) backlighting.
- The first computer monitors used Cathode Ray Tubes (CRTs). Prior to the advent of home computers in the late 1970s, it was common for a Video Display Terminal (VDT) using a CRT to be physically integrated with a keyboard and other components of the system in a single large chassis.
- There are multiple technologies that have been used to implement Liquid Crystal Displays (LCD).
- Organic Light-Emitting Diode (OLED) monitors provide higher contrast, better color reproduction and viewing angles than LCDs.
- OLED require more power when displaying documents with white or bright backgrounds and have a severe problem known as burn-in, just like CRTs.
- OLED are less common than LCD monitors and are often more expensive.

NOTES

- Luminance is measured in candelas per square meter (cd/m^2, also called a *nit*).
- Color depth is measured in bits per primary color or bits for all colors.
- Display resolution is the number of distinct pixels in each dimension that can be displayed. For a given display size, maximum resolution is limited by dot pitch or DPI.
- Dot pitch or pixel pitch represents the size of the primary elements of the display.
- In CRTs, dot pitch is defined as the distance between sub-pixels of the same color.
- In LCDs it is the distance between the centre of two adjacent pixels. Dot pitch is the reciprocal of pixel density.
- Response time is the time a pixel in a monitor takes to change between two shades. The shades depend on the test procedure, which differs between manufacturers. In general, lower numbers mean faster transitions and therefore fewer visible image artifacts such as ghosting.
- Input latency is the time it takes for a monitor to display an image after receiving it, typically measured in milliseconds (ms).
- Contrast ratio is the ratio of the luminosity of the brightest color (white) to that of the darkest color (black) that the monitor can produce simultaneously.
- A Web page is a hypertext document provided by a Website and displayed to a user in a Web browser.
- A Website typically consists of many Web pages linked together in a coherent fashion.
- The name 'Web page' is a metaphor of paper pages bound together into a book. The core element of a Web page is one or more text files written in the HyperText Markup Language (HTML).
- Static pages are retrieved from the Web server's file system without any modification, while dynamic pages must be created by the server on the fly, typically reading from a database to fill out a template, before being sent to the user's browser.
- The screen components must be organised logically, meaningfully, and sensibly for the user to easily maintain the information on the screen in his or her short-term memory.
- Visually pleasing composition refers to the contrast between screen elements, create groupings.
- Users are influenced by the symmetrical balance and weight of the titles, graphics, text, when scanning the interfaces initially.

NOTES

- Visually pleasing composition draws users' attention inherently and makes positive impact on the user's mind.
- The visual techniques like balance, symmetry, regularity, predictability, sequentially, economy, unity and grouping will augment visual pleasing composition of user screen.
- Balance can be achieved by providing an equal weight of screen elements, left and right, top and bottom.
- Regularity as a uniformity of elements based on some principle or plan.
- Regularity can also be placed into the screen by using elements or controls of similar size, shape, color and spacing.
- Predictability denotes a well-established order or strategy. When a user looks at one screen, he or she can predict how another will appear.
- Spontaneity is the opposite of predictability, characterized by a lack of planning or pattern for the components displayed on the user interface.
- Sequentially is a plan of presentation to guide the eye through the screen in a logical, rhythmic order, with the most important information significantly placed.
- Application should be efficient enough to have minimize eye and hand movements.
- A responsive application is comparable to all devices and platforms. While in earlier days there were many Websites which were not compatible to mobile or were not giving the same look and feel as standalone machine.

8.8 KEY WORDS

- **Organic Light-Emitting Diode (OLED):** It monitors provide higher contrast, better color reproduction and viewing angles than LCDs.
- **Display resolution:** It is the number of distinct pixels in each dimension that can be displayed.
- **Response time:** It is the time a pixel in a monitor takes to change between two shades. The shades depend on the test procedure, which differs between manufacturers.
- **Input latency:** It is the time it takes for a monitor to display an image after receiving it, typically measured in milliseconds (ms).
- **Contrast ratio:** It is the ratio of the luminosity of the brightest color (white) to that of the darkest color (black) that the monitor can produce simultaneously.

NOTES

- **Web page:** Itis a hypertext document provided by a Website and displayed to a user in a Web browser.
- **Website:** IT typically consists of many Web pages linked together in a coherent fashion.
- **Predictability:** It denotes a well-established order or strategy. When a user looks at one screen, he or she can predict how another will appear.
- **Spontaneity:** It is the opposite of predictability, characterized by a lack of planning or pattern for the components displayed on the user interface.
- **Sequentially:** It is a plan of presentation to guide the eye through the screen in a logical, rhythmic order, with the most important information significantly placed.

8.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are the elements of screen?
2. What is test for a good design?
3. How to achieve clarity?
4. What are the qualities in visually pleasing composition?
5. What are the components of a statically graphic?

Long-Answer Questions

1. Discuss about screen and its purpose giving suitable examples.
2. How can you organise the screen elements? Discuss in detail with the help of examples.
3. Elaborate on the screen navigation process by giving appropriate examples.
4. Explain the visually pleasing composition of a screen. Give suitable examples.

8.10 FURTHER READINGS

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BLOCK - III
WINDOW CHARACTERISTICS-SOFTWARE TOOLS

NOTES

UNIT 9 WINDOWS CHARACTERISTICS

Structure

9.0 Introduction
9.1 Objectives
9.2 Windows
  9.2.1 Characteristics of Windows 7
9.3 Types of Windows
9.4 Windows Management Framework 3.0
9.5 Windows Presentation Style
9.6 Getting Started With Windows 7
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  9.6.2 Performance Improvements
  9.6.3 Creating HomeGroup in Windows 7
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9.8 Answers to Check Your Progress Questions
9.9 Summary
9.10 Key Words
9.11 Self Assessment Questions and Exercises
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9.0 INTRODUCTION

Windows 7 is a major release of the Windows NT operating system developed by Microsoft. It is the successor to Windows Vista, released nearly three years earlier. It remained an operating system for use on personal computers, including home and business desktops, laptops, tablet PCs and media centre PCs.

Windows 7 was intended to be an incremental upgrade to Microsoft Windows, addressing Windows Vista's poor critical reception while maintaining hardware and software compatibility. Windows 7 continued improvements on Windows Aero (the user interface introduced in Windows Vista) with the addition of a redesigned taskbar that allows applications to be "pinned" to it, and new window management features. Other new features were added to the operating system, including libraries, the new file-sharing system HomeGroup, and support for multitouch input. A new "Action Center" interface was also added to provide an overview of system security and maintenance information, and tweaks were made to the User Account Control system to make it less intrusive.

NOTES

Windows 7 also shipped with updated versions of several stock applications, including Internet Explorer 8, Windows Media Player, and Windows Media Center.

Window management in Windows 7 has several new features. Aero Snap maximizes a window when it is dragged to the top, left, or right of the screen. Dragging windows to the left or right edges of the screen allows users to snap software windows to either side of the screen, such that the windows take up half the screen. When a user moves windows that were snapped or maximized using Snap, the system restores their previous state. Snap functions can also be triggered with keyboard shortcuts. *Aero Shake* hides all inactive windows when the active window's title bar is dragged back and forth rapidly. Windows 7 includes 13 additional sound schemes, titled Afternoon, Calligraphy, Characters, Cityscape, Delta, Festival, Garden, Heritage, Landscape, Quirky, Raga, Savanna, and Sonata. Internet Spades, Internet Backgammon, and Internet Checkers, which were removed from Windows Vista, were restored in Windows 7. Users can disable or customize many more Windows components than was possible in Windows Vista. New additions to this list of components include Internet Explorer 8, Windows Media Player 12, Windows Media Center, Windows Search, and Windows Gadget Platform. A new version of Microsoft Virtual PC, newly renamed as Windows Virtual PC was made available for Windows 7 Professional, Enterprise, and Ultimate editions. It allows multiple Windows environments, including Windows XP Mode, to run on the same machine. Windows XP Mode runs Windows XP in a virtual machine and displays applications within separate windows on the Windows 7 desktop.

In this unit, you will study about the significance Windows 7 and its various components, new features of Windows. Types of Windows, presentation style of Windows, performance improvements and troubleshooting concept in Windows 7.

9.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of Windows 7
- Interpret the significance of new features of Window 7
- Learn about the components of Windows 7
- Know about the different types of Windows 7
- Discuss about the Windows 7 presentation style
- Learn about the performance improvements of Window 7
- Know about the troubleshooting concept

9.2 WINDOWS

NOTES

Microsoft produced **Windows 7** as an operating system to be used on personal computers (both home and business desktops0, laptops, netbooks, tablet PCs and media center PCs. It was released in July 22, 2009, and became available worldwide on October 22, 2009 three years after the release of its predecessor, Windows Vista. Windows 7 is succeeded by Windows 8. The logo of Windows 7 is shown on the right.

Technically, Windows 7 had various incremental upgrade exclusively designed to work with Vista compatible applications and hardware. Microsoft has included the unique features in Windows 7, such as multi-touch support, an updated Windows shell with a new taskbar, referred to internally as the **Superbar**, a home networking system called **HomeGroup** and performance improvements. Some standard applications that have been included with prior releases of Microsoft Windows, including Windows Calendar, Windows Mail, Windows Movie Maker and Windows Photo Gallery, are not included in Windows 7; but most of the applications are offered separately at no charge as part of the Windows Essentials suite.

9.2.1 Characteristics of Windows 7

The following are the new features that are included in Windows 7:

- Advancements in touch and handwriting recognition.
- Support for virtual hard disks.
- Improved performance on multi-core processors.
- Improved boot performance, DirectAccess and kernel specifications.
- Support for systems using multiple heterogeneous graphics cards from different vendors (Heterogeneous Multi-adapter).
- A new version of Windows Media Center and a Gadget for Windows Media Center.
- Improved media features.
- Inclusion of XPS Essentials Pack and Windows PowerShell.
- Redesigned Calculator with multi-line capabilities including *Programmer* and *Statistics* modes along with unit conversion for length, weight, temperature, etc.
- Inclusion of new items to the Control Panel, including ClearType Text Tuner, Display Color Calibration Wizard, Gadgets, Recovery, Troubleshooting, Workspaces Center, Location and Other Sensors, Credential Manager, Biometric Devices, System Icons and Display.

NOTES

- Windows Security Center has been renamed to Windows Action Center (Windows Health Center and Windows Solution Center in earlier builds), which encompasses both security and maintenance of the computer.
- ReadyBoost on 32-bit editions now supports up to 256 gigabytes of extra allocation.
- Windows 7 also supports images in RAW image format through the addition of Windows Imaging Component enabled image decoders, which enables raw image thumbnails, previewing and metadata display in Windows Explorer, plus full-size viewing and slideshows in Windows Photo Viewer and Windows Media Center.

The following are some significant features available in Windows 7.

64-Bit Support

Nowadays the PCs or computers have 64-bit processors and provide advanced features. Basically, a 64-bit PC can hold larger amounts of information in comparison to a 32-bit system. The Windows 7 is compatible for both the types of system, 64-bit processors and 32-bit processors. All packaged retail editions of Windows 7 (except for Home Basic) include both 32- and 64-bit software. Visit the **Windows 7 Compatibility Center** to search a regularly updated list of programs and devices. Check Control Panel to see whether your PC is capable of running the 64-bit version of Windows 7.

Accessibility

Windows 7 has a range of accessibility features that help you to interact with your PC. It includes speech recognition and touch technology.

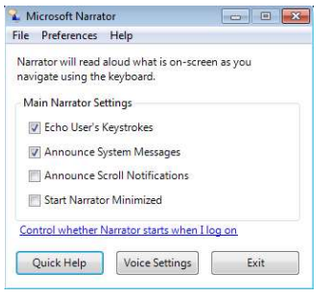
Speech: Windows Speech Recognition has advanced features. Instead of using the keyboard, the user can instruct the computer what to do. For example, composing an e-mail by speaking the recipient's name (the name must be in the address book), surfing the Web without using a keyboard or creating documents by dictating. Windows Speech Recognition responds to the user voice.

Magnifier: Magnifier zooms in on your desktop. Magnifier provides help to the users who have low vision. But other users also use this feature to enlarge the text and pictures which are not readable/clear. Full screen mode magnifies the entire desktop and lens mode zooms the specified areas of the screen. Inside the Magnifier window, you can click buttons and input text normally.

On-Screen Keyboard: On-Screen Keyboard helps you to work without using a physically attached keyboard. Thus it provides on-screen keyboard with a option of several different input methods, such as clicking mode, hovering mode and scanning mode. With **Windows Touch** interface and the right hardware, you can also input text by tapping directly on the screen.

Narrator and Visual Notifications: Windows 7 can read on-screen text aloud and can also describe some events, such as error messages. This feature helps the user to use the computer system when there is no display. With Audio

Description, you can hear a narration of sequence of related events in a video. Windows can also replace sound alerts with visual cues like a screen flash.



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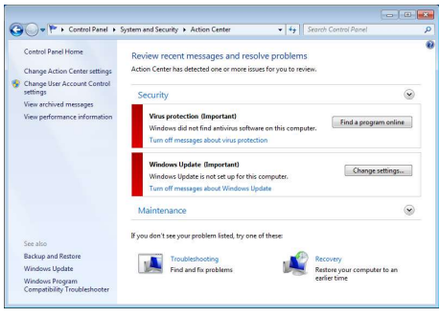
Action Center: Action Center notifies the user(s) whenever items have to be modified. It also helps keep Windows running smoothly.

Action Center provides options to decide which Windows 7 alerts you want to see and which you do not. Action Center consolidates alerts from key Windows maintenance and security features, including Windows Error Reporting, Windows Defender and User Account Control. If Windows requires your attention, the Action Center icon appears in the taskbar. Click it and you will see alerts and suggested fixes for any problems. You can modify your choices in Control Panel.



Aero: The Aero desktop is available in the Home Premium, Professional, Ultimate and Enterprise editions of Windows 7. It mixes graphics with useful new ways to manage your desktop. Aero visual hallmarks include subtle animations and translucent glass windows, which you can personalize. Using Aero, when you point to a **taskbar** button, you will see that a thumbnail-sized preview appears even for live video. Point to the thumbnail, so that it morphs into a full-screen preview. **Shake** and **Peek** cut through desktop clutter by quickly minimizing open windows or turning them invisible.

Backup and Restore: Set it with Backup and Restore. Backup and Restore are specifically improved for Windows 7. It creates safety copies of your most important personal files hence there is hardly any loss of data. You can create back up to another drive or a DVD. If you are using the Professional or Ultimate editions of Windows 7, then you have the option of backing up your files to a network.

NOTES

BitLocker Drive Encryption: Using BitLocker drive encryption, you can protect your data from loss, theft or hackers. This feature is made advanced and improved for Windows 7 and is available in the Ultimate and Enterprise editions. BitLocker help you to keep documents and passwords safer by encrypting the entire drive on which the Windows and your data reside. Once BitLocker is turned on, any file you save on that drive is encrypted automatically.

Features Removed in Windows 7

In Windows 7, certain capabilities and programs are removed which were the specialties of Windows Vista, resulting in the removal of certain functionalities. These include the classic Start Menu user interface, some taskbar features, Windows Explorer features, Windows Media Player features, Windows Ultimate Extras and InkBall. Four applications bundled with Windows Vista – Windows Photo Gallery, Windows Movie Maker, Windows Calendar and Windows Mail – are not included with Windows 7, but applications with close functionality are instead available for free in a separate package called Windows Live Essentials which can be downloaded on the Microsoft Website.

9.3 TYPES OF WINDOWS

Windows 7 is available in six different editions, of which the Home Premium, Professional and Ultimate editions are available for retail sale to consumers in most countries. The other editions are not available in retail. The Starter edition is only available preinstalled by OEMs on new PCs, the Enterprise edition only by volume licensing, and Home Basic only to certain developing countries' markets. Each edition of Windows 7 includes all of the capabilities and features of the edition below it.

All editions support the IA-32 computer architecture, except the Starter edition that support the x86-64 architecture. Retail copies of Windows 7 are distributed on two DVDs: one for the IA-32 version and the other for x86-64. OEM copies include one DVD, depending on the processor architecture licensed. The installation media is the same for all consumer editions of Windows 7 that have the same processor architecture. Product license is used to determine which features are activated. License upgrades permit the subsequent unlocking of features without re-installation of the operating system. Users who wish to upgrade to an edition of Windows 7 with more features can then use Windows Anytime Upgrade to purchase the upgrade, and unlock the features of those editions.

The different editions of Windows 7 have been designed and marketed toward people with different needs. Out of the different editions (Starter, Home Basic, Home Premium, Professional, Enterprise and Ultimate), the Starter edition has been designed and marketed for lower cost notebooks, Home Basic for

emerging markets, Home Premium for normal home users, Professional for businesses, Enterprise for larger businesses and corporations and Ultimate for enthusiasts.

NOTES

1. Main Editions

Windows 7 Starter: Windows 7 Starter is the edition of Windows 7 that contains the fewest features. It is only available in a 32-bit version and does not include the Windows Aero theme. The desktop wallpaper and visual styles (Windows 7 Basic) is not user changeable. This edition is available pre-installed on computers, especially netbooks, through system integrators or computer manufacturers using OEM licenses.

Windows 7 Home Basic: Windows 7 Home Basic is available in 'emerging markets', in 141 different countries. Some Windows Aero options are excluded along with several new features. Home Basic, along with other editions sold in emerging markets, include geographical activation restriction which requires users to activate Windows within a certain region or country.

Windows 7 Home Premium: This edition contains features aimed at the home market segment, such as Windows Media Center, Windows Aero and multi-touch support.

Windows 7 Professional: This edition is targeted towards enthusiasts and small business users. It includes all the features of Windows 7 Home Premium and adds the ability to participate in a Windows Server domain. Additional features include operating as a Remote Desktop server, location aware printing, Encrypting File System, Presentation Mode, Software Restriction Policies (but not the extra management features of AppLocker) and Windows XP Mode.

Windows 7 Enterprise: This edition targets the enterprise segment of the market and is sold through volume licensing to companies which have a Software Assurance contract with Microsoft. Additional features include support for Multilingual User Interface (MUI) packages, BitLocker Drive Encryption and UNIX application support. This edition is not available through retail or OEM channels, but this edition is distributed through Microsoft Software Assurance (SA).

Windows 7 Ultimate: Windows 7 Ultimate contains the same features as Windows 7 Enterprise, but unlike the Enterprise edition, it is available to home users on an individual license basis. Windows 7 Home Premium and Windows 7 Professional users can upgrade to Windows 7 Ultimate by depositing a fee using Windows Anytime Upgrade.

As specified by Microsoft, all these editions will receive Mainstream Support (new features and bug fixes) until January 2015 and Extended Support (security updates) until January 2020.

NOTES

2. Special Purpose Editions

The above mentioned main editions also can take the form of one of the following special editions:

N and KN Editions: The features in the N and KN Editions are the same as their equivalent full versions, but do not include Windows Media Player or other Windows Media related technologies, such as Windows Media Center and Windows DVD Maker.

VL Builds: VL builds work with VLKs (Volume License Keys). Volume license keys can be used to activate multiple installations of the software without any mechanism (such as, a product activation mechanism) checking the total number of installations. The license for the software will place restrictions on the use of the key. Typically, the license will limit the key to a fixed number of installations which must only be within the licensee's organization.

3. Upgrade Editions

Windows Vista Service Pack 1 can be upgraded to Windows 7 with an in-place upgrade if the processor architecture, comparable edition and language version are the same.

4. Standard Upgrade Editions

Upgrading from an applicable version of XP and Vista to an applicable version of Windows 7 is supported using upgrade editions. To upgrade, Windows Vista Service Pack 1 is used. Users can upgrade to Vista first then to Windows 7 or can use Windows Easy Transfer to collect data and settings from installed programs, install Windows 7 then install their program data and settings from Windows Easy Transfer, then re-install all their programs.

5. Family Pack

Windows 7 is available as a Family Pack upgrade edition to upgrade to Windows 7 Home Premium only. It gives licenses to upgrade three machines from Vista or Windows XP to the Windows 7 Home Premium edition. These are not full versions, so each machine to be upgraded must have one of these qualifying previous versions of Windows for them to work.

6. Upgrade Compatibility

The following are two feasible methods to upgrade to Windows 7 from an earlier version of Windows:

- Using an in-place install labelled as 'Upgrade' in the installer. In this, settings and programs are preserved from an older version of Windows. This option is only available depending on the editions of Windows being used and is not available in all versions of Windows Vista.
- Using a clean install labelled as 'Custom' in the installer. In this, all settings including user accounts, applications, user settings, music, photos and programs are erased entirely and also the current operating system is erased

and replaced with Windows 7. This option is always available and is required for versions earlier and up to Windows XP.

7. Anytime Upgrade Editions

NOTES

Windows 7 also supports in-place upgrades from a lower edition of Windows 7 to a higher one using the Windows Anytime Upgrade tool. Currently, there are no plans for family pack versions of the Anytime Upgrade editions. It is possible to use the Product Key from a Standard upgrade edition to accomplish an in-place upgrade, for example Home Premium to Ultimate.

Check Your Progress

1. What unique features has Microsoft included in Windows 7?
2. State the significance of a magnifier in Windows 7.
3. What is an aero desktop?
4. List the features in Windows 7 Home Premium.

9.4 WINDOWS MANAGEMENT FRAMEWORK 3.0

Windows Management Framework 3.0 is an update package that includes updated versions Windows PowerShell (v3.0), Windows Management Instrumentation (WMI) and Windows Remote Management (WinRM). It was released on 3 December 2012.

Hardware Requirements

The following Table 9.1 summarizes the minimum standard hardware requirements for Windows 7.

Table 9.1 *Minimum Hardware Requirements for Windows 7*

Architecture	32-Bit	64-Bit
Processor	1 GHz IA-32 processor	1 GHz x86-64 processor
Memory (RAM)	1 GB	2 GB
Graphics Card	DirectX 9 graphics processor with WDDM driver model 1.0 (Not absolutely necessary; only required for Aero)	
HDD Free Space	16 GB of free disk space	20 GB of free disk space
Optical Drive	DVD-ROM drive (Only to install from DVD-ROM media)	

Additional requirements based on certain features:

- Windows XP Mode (Professional, Ultimate and Enterprise) requires an additional 1 GB of RAM and additional 15 GB of available hard disk space.
- Windows Media Center (included in Home Premium, Professional, Ultimate and Enterprise) requires a TV tuner to receive and record TV.

NOTES

Hardware Support Limits

The following are standard limits for supporting hardware in Window 7.

Physical Memory: Maximum limits on physical memory (RAM) that Windows 7 can address vary depending on both the Windows version and between 32-bit and 64-bit versions. The following Table 9.2 specifies the maximum physical memory limits supported:

Table 9.2 *Physical Memory Limits for Windows 7*

Version	Limit in 32-Bit Windows	Limit in 64-Bit Windows
Windows 7 Ultimate	4 GB	192 GB
Windows 7 Enterprise	4 GB	192 GB
Windows 7 Professional	4 GB	192 GB
Windows 7 Home Premium	4 GB	16 GB
Windows 7 Home Basic	4 GB	8 GB
Windows 7 Starter	2 GB	NA

Processor

The maximum total number of logical processors in a PC that Windows 7 supports is 32 for 32-bit, 256 for 64-bit. Typically, the maximum number of physical processors in a PC that Windows 7 supports is 2 for Professional, Enterprise and Ultimate; and 1 for Starter, Home Basic and Home Premium.

PCs with Multi-Core Processors: Windows 7 was designed to work with multi-core processors. All 32-bit versions of Windows 7 can support up to 32 processor cores, while 64 bit versions can support up to 256 processor cores.

PCs with Multiple Processors (CPUs): Commercial servers, workstations and other high-end PCs may have more than one physical processor. Windows 7 Professional, Enterprise and Ultimate allow two physical processors, providing the best performance on these computers. Windows 7 Starter, Home Basic and Home Premium will recognize only one physical processor.

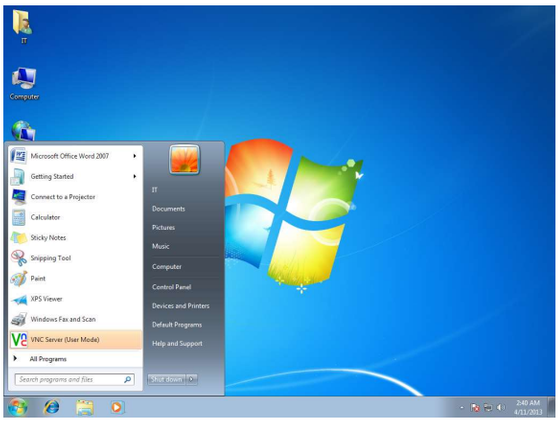
Components of Windows 7

The **Start menu** is a user interface element used in Microsoft Windows operating systems. It provides a central launching point for application and tasks. Depending on the operating system or window manager, the menu might have different names. Traditionally, the Start menu provided a customizable nested list of programs for the user to open, as well as a list of most recently opened documents, a way to find files and get help and access to the system settings. The enhanced features, such as Windows Desktop Update included access to special folders like 'My Documents' and 'Favorites' (browser bookmarks). The Start menu covers a fixed portion of the screen.

NOTES

The Start Button

The Start menu can be opened by either the ? Win Windows key on a keyboard, its equivalent on a tablet device or by clicking on the visual Start button seen on the taskbar are of Windows. On the Windows 7 desktop, the word 'Start' has been replaced by a blue Windows 'orb' logo. However the user can revert to displaying the word 'Start' and the Windows Logo by setting the theme to *Windows Classic*. The Start screen is accessed either by that button or by clicking the lower left corner of the screen. The following screenshot is of Windows 7 which illustrates its desktop, taskbar, Start menu and the glass effect of Windows Aero.

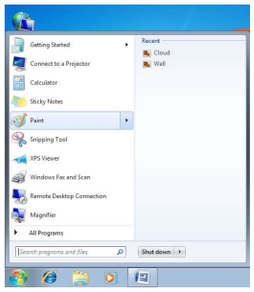


Working with the Start Menu

In Windows 7, you have much more control over the programs and files that appear on the Start menu. The Start menu is essentially a blank slate that you can organize and customize to suit your preferences.

Jump Lists

Windows 7 introduces Jump Lists for both the Start menu and the taskbar. Jump Lists are lists of recent items, such as files, folders, or websites, organized by the program you use to open them. In addition to being able to open recent items using a Jump List, you can also pin favorite items to a Jump List, so that you can easily access the programs and files you use every day. The same items appear in a program's Jump List on the Start menu and on the taskbar.

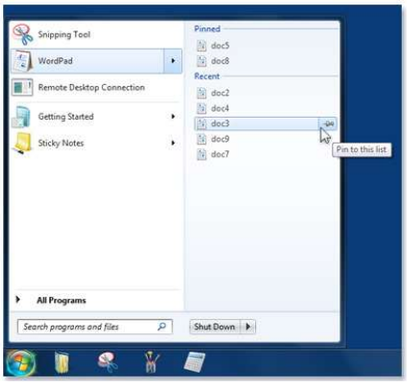


NOTES

By default, no programs or files are pinned to the Start menu to begin with. After you open a program or an item for the first time, it will appear in the Start menu, but you can choose to remove it, or you can pin it to the Start menu so that it always appears there. You can also adjust the number of shortcuts that appear in the Start menu so that it does not get too large.

Working with Jump Lists on the Start Menu

Jump Lists on the Start menu give you quick access to the things you use most often. Pinning an item to the Jump List on the Start menu, the following screen appears.



To view the Jump List for a program:

- Click Start, point to a pinned program or to a recently used program near the top of the Start menu, and then point to or click the arrow next to the program.

To open an item:

- Click Start, point to a pinned program or to a recently used program near the top of the Start menu to open the program's Jump List, and then click the item.

To pin an item to a Jump List:

- Click Start, and then open the program's Jump List.
- Point to the item, click the pushpin icon, and then click Pin to this list.

To unpin an item:

- Click Start, and then open the Jump List for the program.
- Point to the item, click the pushpin icon, and then click Unpin from this list.

Notes: The next time you open an item that you've unpinned, it might reappear in the Jump List. To remove an item from the list, right-click the item and then click Remove from this list.

NOTES

Working with Jump Lists on the Taskbar

Jump Lists on the taskbar give you quick access to the things you use most often. Pinning an item to a Jump List on the taskbar the following screen appears.

To view the Jump List for a program:

- Right-click the program's button on the taskbar.

To open an item from a Jump List:

- Open the program's Jump List, and then click the item.

To pin an item to a Jump List:

- Open the program's Jump List, point to the item, click the pushpin icon, and then click Pin to this list.

Notes:

- You can also drag a file icon or a shortcut from the Start menu or the desktop to the taskbar. This pins the item to the Jump List and also pins the program to the taskbar, if it isn't pinned already.
- Folders are considered Windows Explorer items and appear in the Windows Explorer Jump List when pinned or opened.

To Unpin an Item

- Open the program's Jump List, point to the item, click the pushpin icon, and then click Unpin from this list.
- The next time you open an item that you have unpinned, it might reappear in the Jump List. To remove an item from the list, right-click the item, and then click Remove from this list.

Libraries

In previous versions of Windows, managing your files meant organizing them in different folders and subfolders. In Windows 7, you can also use libraries to organize and access files by type, regardless of where they are stored.

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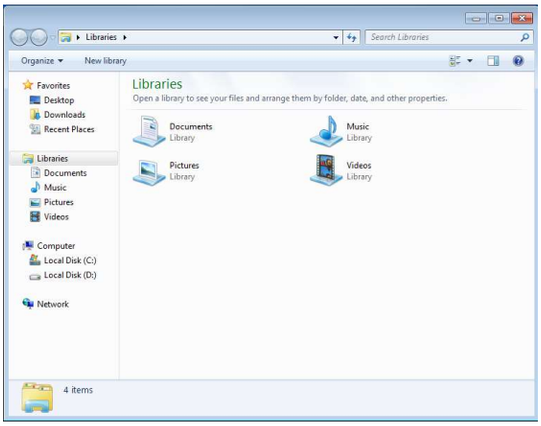
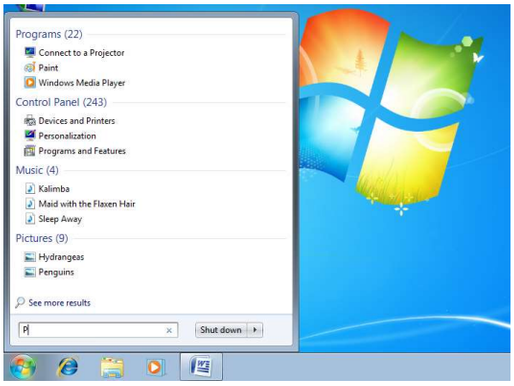


A library gathers files from different locations and displays them as a single collection, without moving them from where they are stored. There are four default libraries (Documents, Music, Pictures, and Videos), but you can create new libraries for other collections. The Documents, Music, and Pictures libraries appear on the Start menu by default. Like other items on the Start menu, you can add or remove libraries, or customize their appearance.

Search

The Start menu includes a search box that you can use to find files, folders, programs and e-mail messages stored on your computer. When you start typing a word or phrase in the search box, the search begins automatically and the search results temporarily fill the Start menu space above the search box.

The search results are organized into groups, depending on what kind of item each result is and where it's located on your computer. For example, you might see your search results grouped by Programs, by Control Panel tasks, by library (such as, Documents or Pictures) and by Files. The top search results for each group are displayed under a group heading. You can click an individual result to open that program or file, or you can click a group heading to see the complete list of search results for that group in Windows Explorer.



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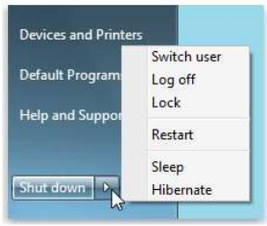
Power Button Options

The Shut down button appears in the lower right corner of the Start menu. Click the arrow next to the Shut down button for more options.

When you click Shut down, your computer closes all open programs and shuts down your computer. You can choose to have this button perform a different action, such as putting your computer into sleep mode or allowing a different user to log on.



Some familiar buttons have been changed or removed from the Start menu in Windows 7 (but you can add them back if you want to).

- The Connect To button, which provided a list of available networks you could choose to connect to, has been removed. To see the list of available networks, click the Networking icon in the notification area at the end of the taskbar and then click Open Network and Sharing Center.
- The Printers button is now the Devices and Printers button. You can click this button to display a list of all peripheral devices connected to your computer, including printers, faxes, monitors and your mouse.
- The Network button has been removed from the Start menu, but it appears in the navigation pane of Windows Explorer. You can click the Network button to display a list of all the computers connected to your current network.
- The Recent Items button has been removed from the Start menu, although the files and programs you've recently opened will still appear in the Jump List for the Start menu automatically. You can also add the Recent Items button back to the Start menu if you prefer.

You might also notice that the classic Start menu option, which gave your Start menu the look and functionality of previous versions of Windows, is no longer available in Windows 7.

Customize the Start Menu

Organizing the Start menu can make it easier to find your favorite programs and folders.

NOTES

To Pin a Program Icon to the Start Menu

- If you use a program regularly, you can create a shortcut to it by pinning the program icon to the Start menu. Pinned program icons appear on the left side of the Start menu.
- Right-click the program icon you want to pin to the Start menu, and then click Pin to Start Menu.

Notes

- To unpin a program icon, right-click it and then click Unpin from Start Menu.
- To change the order of a pinned item, drag the program icon to a new position in the list.

To Remove a Program Icon from the Start Menu

Removing a program icon from the Start menu doesn't remove it from the All Programs list or uninstall the program.

1. Click the Start button .
2. Right-click the program icon you want to remove from the Start menu, and then click Remove from this list.

To Move the Start Button

The Start button is located on the taskbar. Although you can not remove the Start button from the taskbar, you can move the taskbar and the Start button along with it.

- Right-click an empty space on the taskbar. If Lock the taskbar has a check mark beside it, click it to remove the check mark.
- Click an empty space on the taskbar, and then hold down the mouse button as you drag the taskbar to one of the four edges of the desktop. When the taskbar is where you want it, release the mouse button.

Note: To lock the taskbar into place, right-click an empty space on the taskbar, and then click Lock the Taskbar so that the check mark reappears. Locking the taskbar helps prevent it from being moved or resized accidentally.

To Clear Recently Opened Files or Programs from the Start Menu

Clearing recently opened files or programs from the Start menu does not delete them from your computer.

- Open Taskbar and Start Menu Properties by clicking the Start button , clicking Control Panel, clicking Appearance and Personalization, and then clicking Taskbar and Start Menu.
- Click the Start Menu tab. To clear recently opened programs, clear the Store and display recently opened programs in the Start menu check box. To clear recently opened files, clear the Store and display recently opened items in the Start menu and the taskbar check box and then click OK.

NOTES

To Adjust the Number of Shortcuts for Frequently Used Programs

The Start menu displays shortcuts for the programs you use most frequently. You can change the number of program shortcuts displayed. This can affect the height of the Start menu.

- Open Taskbar and Start Menu Properties by clicking the Start button, clicking Control Panel, clicking Appearance and Personalization, and then clicking Taskbar and Start Menu.
- Click the Start Menu tab, and then click Customize.
- In the Customize Start Menu dialog box, in the Number of recent programs to display box, enter the number of programs you want to display on the Start menu, click OK and then click OK again.

To Customize the Right Pane of the Start Menu

You can add or remove items, such as Computer, Control Panel, and Pictures, that appear on the right side of the Start menu. You can also change some items so that they appear as links or menus.

- Open Taskbar and Start Menu Properties by clicking the Start button, clicking Control Panel, clicking Appearance and Personalization, and then clicking Taskbar and Start Menu.
- Click the Start Menu tab, and then click Customize.
- In the Customize Start Menu dialog box, select the options in the list that you want, click OK, and then click OK again.

To Restore Start Menu Default Settings

You can restore the Start menu to its original, default settings.

- Open Taskbar and Start Menu Properties by clicking the Start button, clicking Control Panel, clicking Appearance and Personalization, and then clicking Taskbar and Start Menu.
- Click the Start Menu tab and then click Customize.
- In the Customize Start Menu dialog box, click Use Default Settings, click OK and then click OK again.

To Search for Programs from the Start Menu

- Click the Start button, and then type a word or phrase in the search box.

To Add the Run Command to the Start Menu

- Open Taskbar and Start Menu Properties by clicking the Start button, clicking Control Panel, clicking Appearance and Personalization and then clicking Taskbar and Start Menu.
- Click the Start Menu tab, and then click Customize.

- In the Customize Start Menu dialog box, scroll through the list of options to find the Run command check box, select it, click OK and then click OK again.

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To Add Recent Items to the Start Menu

- Open Taskbar and Start Menu Properties by clicking the Start button , clicking Control Panel, clicking Appearance and Personalization, and then clicking Taskbar and Start Menu.
- Click the Start Menu tab. Under Privacy, select the Store and display recently opened items in the Start menu and the taskbar check box.
- Click Customize. In the Customize Start Menu dialog box, scroll through the list of options to find the Recent Items check box, select it, click OK and then click OK again.

The Windows 7 Taskbar

The taskbar has seen the biggest visual changes, where the Quick Launch toolbar has been replaced with the ability to pin applications to the taskbar. Buttons for pinned applications are integrated with the task buttons.

These buttons also enable the *Jump Lists* feature to allow easy access to common tasks. The revamped taskbar also allows the reordering of taskbar buttons. To the far right of the system clock is a small rectangular button that serves as the *Show desktop* icon. This button is part of the new feature in Windows 7 called *Aero Peek*. Hovering over this button makes all visible windows transparent for a quick look at the desktop. In touch-enabled displays, such as touch screens, tablet PCs, etc., this button is slightly (8 pixels) wider in order to accommodate being pressed by a finger. Clicking this button minimizes all windows and clicking it a second time restores them. Additionally, there is a feature named *Aero Snap* that automatically maximizes a window when it is dragged to the top of the screen. Dragging windows to the left/right edges of the screen allows users to snap documents or files on either side of the screen for comparison between windows, such that the windows vertically take up half the screen. When a user moves windows that were maximized using Aero Snap, the system restores their previous state automatically. This functionality is also accomplished with keyboard shortcuts. Window borders and the taskbar do not turn opaque when a window is maximized with Windows Aero applied. Instead, they remain translucent. Windows 7 includes 13 additional sound schemes, titled Afternoon, Calligraphy, Characters, Cityscape, Delta, Festival, Garden, Heritage, Landscape, Quirky, Raga, Savanna, and Sonata. Internet Spades, Internet Backgammon and Internet Checkers are restored in Windows 7. The new Action Center is displayed below.

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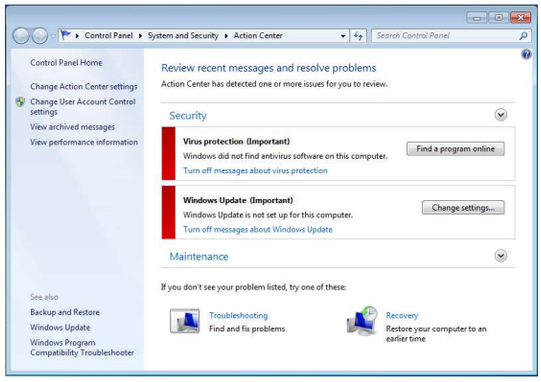
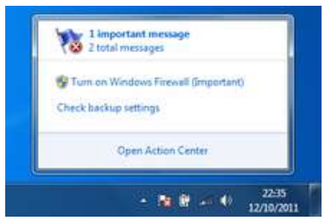


When the Action Center flag is clicked on, it lists all security and maintenance issues in a small popup window as shown below.

Windows 7 supports the mounting of a Virtual Hard Disk (VHD) as normal data storage and the bootloader delivered with Windows 7 can boot the Windows system from a VHD; however, this ability is only available in the Enterprise and Ultimate editions. The Remote Desktop Protocol (RDP) of Windows 7 is also enhanced to support real-time multimedia application including video playback and 3D games, thus allowing use of DirectX 10 in remote desktop environments.



Make Items on the Screen Appear Bigger using Magnifier

Magnifier enlarges different parts of the screen and is part of the Ease of Access Center. To open it quickly, click Start and then type Magnifier.

You can also change the screen resolution, which adjusts the clarity, size and amount of things that fit on your computer monitor.

Notes

- If you want to have Magnifier at your fingertips, you can pin it to the taskbar.
- To exit Magnifier, press the Windows logo key +Esc.

The following are three Magnifier modes:

- Full-screen mode. In full-screen mode, your entire screen is magnified. Depending on the size of your screen and the zoom level you choose, you might not be able to see the entire screen at the same time.
- Lens mode. In lens mode, the area around the mouse pointer is magnified. When you move the mouse pointer, the area of the screen that is magnified moves along with it.

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- Docked mode. In docked mode, only a portion of the screen is magnified, leaving the rest of your desktop unchanged. You can then control which area of the screen is magnified.

Note: Full-screen mode and lens mode are only available as part of the Aero experience. If your computer does not support Aero or if you are not using an Aerotheme, Magnifier will only work in docked mode.

To Make Items on the Screen Appear Bigger

- Open Magnifier by clicking the Start button, clicking All Programs, clicking Accessories, clicking Ease of Access and then clicking Magnifier.
- On the Views menu, click the mode that you want to use.
- Move the pointer to the part of the screen that you want to magnify.

Notes: When you're using full-screen mode, you can quickly preview your entire desktop by clicking the Views menu and then clicking Preview full screen.

Schedule a Task

To schedule a task, log on as an administrator to perform these steps. If you are not logged on as an administrator, you can only change settings that apply to your user account.

If you use a specific program on a regular basis, you can use the Task Scheduler wizard to create a task that opens the program for you automatically according to the schedule you choose. For example, if you use a financial program on a certain day each month, you can schedule a task that opens the program automatically to avoid the risk of forgetting to open it yourself.

- Open Task Scheduler by clicking the Start button, clicking Control Panel, clicking System and Security, clicking Administrative Tools and then double-clicking Task Scheduler. If you are prompted for an administrator password or confirmation, type the password or provide confirmation.
- Click the **Action** menu, and then click **Create Basic Task**.
- Type a name for the task and an optional description and then click **Next**.
- Do one of the following:
    - o To select a schedule based on the calendar, click Daily, Weekly, Monthly or One time, click Next; specify the schedule you want to use and then click Next.
    - o To select a schedule based on common recurring events, click **When the computer starts** or **When I log on**, and then click Next.
    - o To select a schedule based on specific events, click **When a specific event is logged**, click **Next**; specify the event log and other information using the drop-down lists and then click Next.

- To schedule a program to start automatically, click Start a program and then click Next.

- Click Browse to find the program you want to start and then click Next.
- Click Finish.

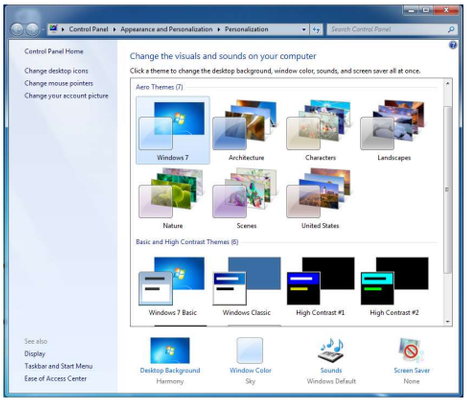
Note: Task Scheduler is a Microsoft Management Console (MMC) snap-in and includes additional help for advanced users. For more information, open Task Scheduler, click the Help menu, and then click Help Topics.

9.5 WINDOWS PRESENTATION STYLE

With Windows 7, it is easier work on the desktop. Windows 7 comes with three simple yet powerful new features called Shake, Peek and Snap to help you instantly clear through desktop clutter.

Spectacular New Wallpapers

Windows 7 includes new desktop backgrounds and wallpapers. Try the new desktop slideshow, which displays a rotating series of pictures. Windows 7 makes it easy to express your personality with creative new themes and other custom touches.



Retooled Taskbar

In Windows 7, the taskbar has been completely redesigned to help you work smarter, cut clutter, and get more done. Improvements to the new Windows 7 taskbar include thumbnail previews of Web pages, documents and even running video.

NOTES

Improved Gadgets

Gadgets are the popular mini-programs. You can stick your gadgets anywhere on the Windows 7 desktop.

Working with New Features with the Windows Desktop

New features on the Windows desktop make it easier to organize and manage multiple windows. You can switch easily between open windows so that you can focus on important programs and files. Other new features help you add a personal touch to your desktop.

Snap

You can use Snap to arrange and resize windows on the desktop with a simple mouse movement. Using Snap, you can quickly align windows at the side of the desktop, expand them vertically to the entire height of the screen, or maximize

NOTES

them to completely fill the desktop. Snap can be especially helpful when comparing two documents, copying or moving files between two windows, maximizing the window you are currently working on or expanding long documents so they're easier to read and require less scrolling.

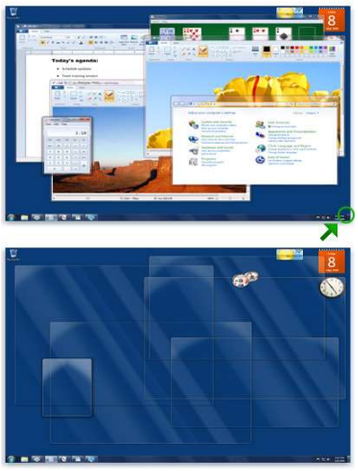
Drag a window to the side of the desktop to expand it to half of the screen. To use Snap, drag the title bar of an open window to either side of the desktop to align it there, or drag it to the top of the desktop to maximize the window. To expand a window vertically using Snap, drag the top edge of the window to the top of the desktop. For more information, search for 'Snap' in Help and Support.

Shake

Using Shake, you can quickly minimize all open windows on the desktop except the one you want to focus on. Just click the title bar of the window you want to keep open and drag (or shake) the window back and forth quickly, and the other open windows are minimized. Shake a window to minimize all other windows.

Peek

You can use Peek features to quickly preview the desktop without minimizing all your windows, or preview an open window by pointing at its button on the taskbar.



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Peek at the Desktop

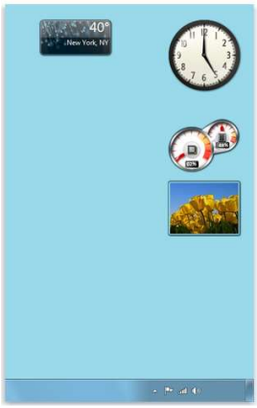
The Show desktop button has been moved the opposite end of the taskbar from the Start button, making it easier to click or point to the button without accidentally opening the Start menu.

In addition to clicking the Show desktop button to get to the desktop, you can temporarily view or peek at the desktop by just pointing to the Show desktop button. When you point to the Show desktop button at the end of the taskbar, any open windows fade from view, revealing the desktop. To make the windows reappear, move the mouse away from the Show desktop button. Quickly view your desktop using Peek.

This can be useful for quickly viewing desktop gadgets, or when you do not want to minimize all open windows and then have to restore them.

Peek at an Open File on the Desktop

You can also use Peek to take a quick look at other open windows without clicking away from the window you are currently working on. Peek at open windows using thumbnails on the taskbar.



Point to a program button on the taskbar that has open files. Thumbnail previews of any open files associated with that program appear above the taskbar. You can point to a thumbnail to preview that window's contents, and all the other open windows on the desktop fade away to reveal just the window you're previewing. To open the window you're previewing, click the thumbnail.

NOTES

Gadgets

Windows Sidebar is not included in this version of Windows. Instead, you can display gadgets anywhere on your desktop and use the Peek features to temporarily view your desktop gadgets without minimizing or closing the windows you're working with.

For more information about using gadgets on your desktop, search for 'gadgets' in Help and Support.

Desktop Background

Your desktop background doesn't have to be a single picture anymore. With Windows 7, you can display a slide show of pictures, instead. Some Windows themes include a slide show, or you can create your own slide show from your personal collection of pictures.

Not all new desktop features are available in all editions of Windows 7. For example, Peek, Shake and background slide shows are not included in Windows 7 Home Basic or Windows 7 Starter. You can find out which edition of Windows 7 you have on your computer by opening System in Control Panel.

- Open System by clicking the Start button , right-clicking Computer and then clicking Properties.

The Start menu and the taskbar have also been redesigned to showcase some new features.

What is the Aero Desktop Experience?

The Aero desktop experience features a translucent glass design with subtle window animations and new window colors.

The Aero desktop experience features glass-like windows for an open look. It includes distinctive visual styles that combine the appearance of lightweight, translucent windows with powerful graphic advances. You can enjoy visually appealing effects and appearance and also benefit from better access to your programs.

NOTES

Glass Effects

Translucent glass windows create depth on the desktop. One of the more visually obvious features is glass window borders, which let you focus on the contents of your open windows. Window behavior has also been redesigned, with subtle animations accompanying the minimizing, maximizing, and repositioning of windows to appear more smooth and effortless.

Tint your windows using the provided colors, or mix your own custom color. You can even fine-tune the color and appearance of windows, the Start menu, and the taskbar by tinting your translucent windows. Select one of the provided colors or create your own custom color using the color mixer.

Switching between Programs

Pointing to a window's taskbar button displays a preview of the window. The Aero desktop experience also includes taskbar previews for your open windows. When you point to a taskbar button, you will see a thumbnail-sized preview of the window, whether the content of the window is a document, a photo, or even a running video.

NOTES

When you press Alt+Tab to switch between windows, you can see live previews of the windows for each open program. The following screen shows switching windows with Alt+Tab.

How do I get the Aero Desktop Experience?

The following editions of Windows 7 include Aero:

Windows 7 Enterprise

Windows 7 Home Premium

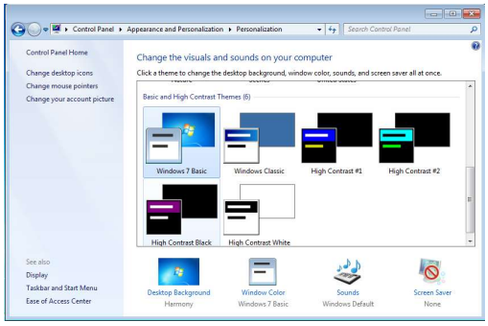
Windows 7 Professional

Windows 7 Ultimate

Aero is not included in Windows 7 Home Basic or Windows 7 Starter. You can find out which edition of Windows 7 you have on your computer by opening System in Control Panel.

- Open System by clicking the **Start** button, right-clicking **Computer** and then clicking **Properties**.

The edition of Windows 7 you are running is displayed under **Windows edition** near the top of the window.



You also need to use a Windows theme to display Aero graphics. If you are using an Ease of Access theme, some elements such as transparency and thumbnail previews will not appear. To view which theme you are using, open Personalization in Control Panel.

- Open Theme Settings by clicking the **Start** button, clicking **Control Panel**, clicking **Appearance and Personalization**, clicking **Personalization**, and then clicking **Theme**.

The theme currently in use is highlighted.

NOTES

Aero Hardware Requirements

Your computer's hardware and video card must meet hardware requirements to able to display Aero graphics. Check that your computer meets the minimum hardware requirements for running Aero:

- 1-gigahertz (GHz) 32-bit (x86) or 64-bit (x64) processor.
- 1 gigabyte (GB) of random access memory (RAM).
- 128-megabyte (MB) graphics card.

Aero also requires a DirectX 9 class graphics processor that supports a Windows Display Driver Model Driver, Pixel Shader 2.0 in hardware and 32 bits per pixel.

For best results, you might also want to follow these graphics processor recommendations:

- 64 MB of graphics memory to support a single monitor with a resolution that is less than 1,310,720 pixels (for example, a 17–inch flat panel LCD monitor that has a 1280 × 1024 resolution).
- 128 MB of graphics memory to support a single monitor with a resolution from 1,310,720 to 2,304,000 pixels (for example, a 21.1–inch flat panel LCD monitor that has up to a 1600 × 1200 resolution).
- 256 MB of graphics memory to support a single monitor with a resolution greater than 2,304,000 pixels (for example, a 30–inch wide-screen flat panel LCD monitor that has up to a 2560 × 1600 resolution).

Check Your Progress

5. What does the maximum limit on physical memory depends?
6. Why is the jump list important?
7. State the significance of library in Windows.
8. What is the role of Remote Desktop Protocol (RDP) of Windows 7?

9.6 GETTING STARTED WITH WINDOWS 7

Getting Started feature helps you work faster on your new PC. Getting Started is a central place for transferring and backing up files, adding user accounts and personalizing Windows 7.

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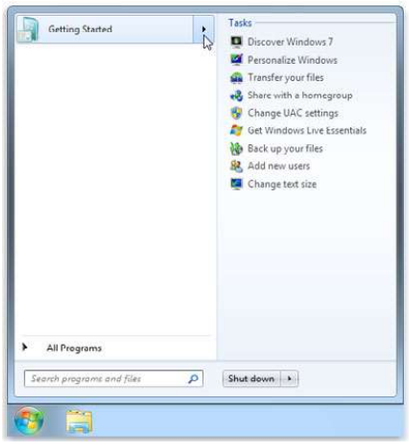


One-Stop Setup

In Windows 7, there's one central place to go when you're setting up a computer. It is called Getting Started. Getting Started is kind of like one-stop shopping for setting up a new PC. It features a list of common setup tasks, like transferring your files, creating user accounts and setting up a home network.

Getting Started is easy to find. Just click the Start button and then point to Getting Started to see a list of setup tasks.

Windows Easy Transfer

Windows Easy Transfer is a step-by-step guide for transferring files and settings from one computer running Windows to another. It helps you choose what to move to your new computer, such as documents, music, pictures, videos, user accounts, Internet favorites and e-mail. It also lets you decide which method to use to transfer your files and then performs the transfer.

Get Connected

Using Windows 7 logo, you can set up connections automatically with Windows Connect Now (WCN).

In Windows 7, the taskbar has been completely redesigned to help you more easily manage and access your most important files and programs. Taskbar buttons have a new look and do more than just show you which programs are running.

In the default view, each program appears as a single, unlabeled button—even when multiple items for a program are open—for a clean and uncluttered look. You can customize the taskbar appearance to change how buttons appear and how they group together when you have multiple items open. You can also choose to see individual buttons for each open file.

NOTES

You can also rearrange and organize buttons on the taskbar, including pinned programs and running programs that aren't pinned, so they appear in the order you prefer. To rearrange the order of buttons on the taskbar, drag a button from its current position to a different position on the taskbar. You can rearrange buttons as often as you like.

9.6.1 Previewing Open Windows with Aero Peek

When you open multiple windows on the desktop, sometimes it can be a challenge to view separate windows and switch between them.

You can use Aero Peek to take a quick look at other open windows without clicking away from the window you are currently working on. Point your mouse at a taskbar button, and thumbnail previews of any open windows associated with that button appear above the taskbar. If you want to open a window you are previewing, just click its thumbnail.

Pinning Items

Pinning programs to the taskbar complements pinning programs to the Start menu, like in earlier versions of Windows. When you pin a favorite program to the taskbar, you can always see it there and easily access it with a single click. Windows 7 also includes **Jump Lists**, so that in addition to launching a program from the taskbar, you can now launch favorite and recent items from that program, just by clicking the same button.

Jump Lists are lists of recently or frequently opened items, such as files, folders, tasks, or Websites, organized by the program that you use to open them. In addition to being able to open recent items using a Jump List, you can also pin favorite items to a Jump List so you can quickly get to the items that you use every day.

On the taskbar, Jump Lists appear for programs that you've pinned to the taskbar and programs that are currently running. You can view the Jump List for a program by right-clicking the taskbar button, or by dragging the button toward the desktop. You open items from the Jump List by clicking them.

Notification Area

A new way of managing the notification area on the end of the taskbar means you get fewer notifications, and the ones you get are collected in a single place in Windows. In the past, the notification area could sometimes become cluttered with icons. Now, you can choose which icons appear visible at all times. And you can keep the rest of the icons on hand in an overflow area, where they're accessible with a single mouse click.

Action Center is a single area that collects important notification messages about security and maintenance settings. You can review these messages later if you don't want to be interrupted. When you click the Action Center icon and

then click **Open Action Center**, you'll see information about the things you need to take action on, and find helpful links to troubleshooters and other tools that can help fix problems.

NOTES

Viewing the Desktop

The **Show desktop** button has been moved to the opposite end of the taskbar from the **Start** button, making it easier to click or point at the button without accidentally opening the Start menu. The following screen shows the Show desktop button on the taskbar.

In addition to clicking the **Show desktop** button to get to the desktop, you can temporarily view or peek at the desktop by just pointing your mouse at the **Show desktop** button, without clicking it. When you point at the **Show desktop** button at the end of the taskbar, any open windows fade from view, revealing the desktop. To make the windows reappear, move the mouse away from the **Show desktop** button.

This can be useful for quickly viewing desktop gadgets, or when you do not want to minimize all open windows and then have to restore them.

Temporarily Preview the Desktop using Peek

You can temporarily view the desktop using Peek. This can be useful for quickly viewing desktop gadgets and folders, or when you do not want to minimize all open windows and then have to restore them.

To temporarily preview the desktop:

- Point to the Show desktop button at the end of the taskbar. The open windows fade from view, revealing the desktop.
- To make the windows reappear, move the pointer away from the Show desktop button.

Notes

- Press the Windows logo key +Spacebar to temporarily preview the desktop. To restore the desktop, release the Windows logo key +Spacebar.
- To minimize open windows so that they remain minimized, click the Show desktop button, or press the Windows logo key +D. To restore the open windows, click the Show desktop button again or press the Windows logo key +D again.

NOTES

To Turn Off Desktop Previews

If you do not want the desktop to fade when you point to the Show desktop button, you can turn off this feature of Peek.

- Open Taskbar and Start Menu Properties by clicking the Start button , clicking Control Panel, clicking Appearance and Personalization, and then clicking Taskbar and Start Menu.
- Under Preview desktop with **Aero** Peek , clear the Use **Aero** Peek to preview the desktop check box, and then click OK.

Note: You can also use Peek to preview an open window on the desktop (and temporarily make other open windows fade).

9.6.2 Performance Improvements

The Windows 7 is designed to be more nimble, efficient and responsive. Key performance improvements include:

Sleep and Resume

Windows 7 is designed to sleep, resume, and reconnect to your wireless network more quickly, so your PC is ready when you are.

Search

When hunting for something, you want answers, not delays. In Windows 7, search results pop up faster. Sorting and grouping of search results is also significantly quicker.

USB Devices

When you plug in a portable flash drive or other USB device for the first time, Windows 7 can often have it ready for you in seconds. If you have used it before, the wait is even shorter.

Better memory use

Windows 7 has under-the-hood tune-ups that can boost your PC's overall speed and performance. It uses less memory when it's idle and less graphics memory when you launch and switch between windows. It is also designed to run background services like Bluetooth only when you need them.

If memory does run low, **ReadyBoost** can speed up your computer by using storage space on most USB flash drives and flash memory cards.

HomeGroup

If you ever find yourself emailing docs to the computer in the next room so you can print them, HomeGroup was designed for you. Now, you can easily connect two or more PCs running Windows 7 on your home network to automatically start

sharing printers and your media and document **libraries** with other people in your workplace/home.

HomeGroup is password protected and hence secured. You decide what gets shared and what stays private. You can also make your files 'read only', so other people can view it but not make any modifications.

You can join a HomeGroup in any edition of Windows 7, but you can only create one in Windows 7 Home Premium, Professional, Ultimate or Enterprise editions.

9.6.3 Creating HomeGroup in Windows 7

A HomeGroup is a group of PCs on a home network that can share files and printers. Using a HomeGroup makes sharing easier. You can share pictures, music, videos, documents, and printers with other people in your HomeGroup.

You can help protect your HomeGroup with a password, which you can change at any time. Other people can't change the files that you share unless you give them permission to do so.

After you create or join a HomeGroup, you select the libraries (for example, My Pictures or My Documents) that you want to share. You can prevent specific files or folders from being shared, and you can share additional libraries later.

In Windows 7 Starter, Windows 7 Home Basic, and Windows RT, you can join a HomeGroup, but you can not create one.

Step 1. Create a HomeGroup

When you set up a PC, a HomeGroup is created automatically. If a HomeGroup already exists on your home network, you can join it.

- Open HomeGroup by swiping in from the right edge of the screen, tapping Settings (or if you're using a mouse, pointing to the upper-right corner of the screen, moving the mouse pointer down, and then clicking Settings), tapping or clicking Change PC settings, and then tapping or clicking HomeGroup.
- Tap or click Create.
- Select the libraries and devices you want to share with the HomeGroup.

If a HomeGroup already exists on your network, you will be asked to join it instead of creating a new one. If your PC belongs to a domain, you can join a HomeGroup but you can not create one. You can get to libraries and devices on other HomeGroup PCs, but you can not share your own libraries and devices with the HomeGroup.

You can join a HomeGroup on a PC running Windows RT, but you can not create a HomeGroup or share content with the HomeGroup. Network sharing must be turned on for HomeGroup to work.

After you create a HomeGroup, the other PCs running Windows 7, Windows 8, or Windows RT on your network can join it.

Step 2. Add your other PCs to the HomeGroup

NOTES

After someone on your network creates a HomeGroup, the next step is to join it. You will need the HomeGroup password, which you can get from any HomeGroup member. All user accounts except the Guest account will belong to the HomeGroup. Each person controls access to his or her own libraries.

- To join a HomeGroup, follow these steps on the PC that you want to add to the HomeGroup:
- Open HomeGroup by swiping in from the right edge of the screen, tapping Settings (or if you're using a mouse, pointing to the upper-right corner of the screen, moving the mouse pointer down, and then clicking Settings), tapping or clicking Change PC settings, and then tapping or clicking HomeGroup.
- Enter the HomeGroup password, and then tap or click Join.

Note

- If you don not see a space to enter a password, there might not be a HomeGroup available. Make sure that someone has created a HomeGroup, or you can create a HomeGroup yourself.
- Select the libraries and devices you want to share with the HomeGroup.
- Tap or click the control under Media devices if you want to allow devices on the network, such as TVs and game consoles, to play your shared content.

Step 3. Find HomeGroup files

PCs that belong to your HomeGroup will appear in File Explorer.

To get to shared libraries on other HomeGroup PCs

- Open File Explorer by swiping in from the right edge of the screen, tapping Search (or if you're using a mouse, pointing to the upper-right corner of the screen, moving the mouse pointer down, and then clicking Search), entering **File Explorer** in the search box, tapping or clicking Apps, and then tapping or clicking File Explorer.
- Under HomeGroup, tap or click the user account name of the person whose libraries you want to get to.
- In the file list, double-tap or double-click the library you want to get to, and then double-tap or double-click the file or folder you want.

Notes

- PCs that are turned off, hibernating, or asleep may not appear as part of the HomeGroup.
- If you have made HomeGroup files or folders available offline, and then you disconnect from the network, the files or folders will no longer be visible in the Libraries window. To find them, open the Network folder.

NOTES

Step 4. Share libraries and devices, or stop sharing them

When you create or join a HomeGroup, you select the libraries and devices you want to share with other people in the HomeGroup. Libraries are initially shared with **Read** access, which means that other people can look at or listen to what's in the library, but they can't change the files in it. You can adjust the level of access at any time, and you can exclude specific files and folders from sharing.

Only those people who belong to the HomeGroup can see shared libraries and devices. You can choose to share libraries, devices, or individual files and folders with specific people in your HomeGroup or with everyone.

Note: Keep in mind that children who use HomeGroup PCs will have access to all shared libraries and devices.

To share devices and entire libraries:

- Open HomeGroup by swiping in from the right edge of the screen, tapping Settings (or if you're using a mouse, pointing to the upper-right corner of the screen, moving the mouse pointer down, and then clicking Settings), tapping or clicking Change PC settings, and then tapping or clicking HomeGroup.
- Select the libraries and devices you want to share with the HomeGroup.

To share individual files or folders

- Open File Explorer by swiping in from the right edge of the screen, tapping Search (or if you're using a mouse, pointing to the upper-right corner of the screen, moving the mouse pointer down, and then clicking Search), entering **File Explorer** in the search box, tapping or clicking Apps, and then tapping or clicking File Explorer.
- Select the item, and then tap or click the Share tab.
- Choose an option in the Share with group. There are different Share with options depending on whether your PC is connected to a network and what kind of network it is.

Step 5. Share a printer

Printers that are connected with a USB cable can be shared with a HomeGroup. After the printer is shared, you can get to it through the Print dialog box in any program, just like a printer that's directly connected to your PC.

To share your printer with the HomeGroup:

- Open HomeGroup by swiping in from the right edge of the screen, tapping Settings (or if you're using a mouse, pointing to the upper-right corner of the screen, moving the mouse pointer down, and then clicking Settings), tapping or clicking Change PC settings, and then tapping or clicking HomeGroup.
- Tap or click the control to share Printers and devices.

NOTES

To print to a HomeGroup printer

- Open the Print menu of the app you want to print from, select the HomeGroup printer, and then tap or click Print.

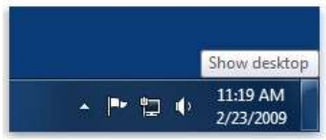
Note: The PC that the printer is connected to must be turned on to use the printer.

Internet Explorer

Internet Explorer 8, which comes with Windows 7, has smart new features, such as search suggestions, Accelerators and Web Slices, so you can quickly get to the Website you are looking for and easily keep up with fast-changing sites.

Viewing the Desktop

The **Show desktop** button has been moved to the opposite end of the taskbar from the **Start** button, making it easier to click or point at the button without accidentally opening the Start menu.

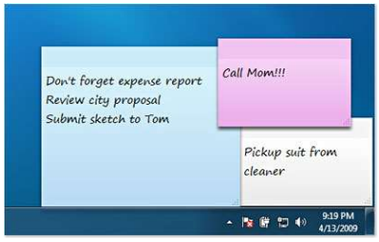


In addition to clicking the **Show desktop** button to get to the desktop, you can temporarily view or peek at the desktop by just pointing your mouse at the **Show desktop** button, without clicking it. When you point at the **Show desktop** button at the end of the taskbar, any open windows fade from view, revealing the desktop. To make the windows reappear, move the mouse away from the **Show desktop** button.

This can be useful for quickly viewing desktop gadgets, or when you don't want to minimize all open windows and then have to restore them.

Sticky Notes

Already as necessary as pencils and paper clips, Sticky Notes just got more useful. In Windows 7, you can format a note's text, change its color with a click, and speedily resize, collapse, and flip through notes. Sticky Notes is available only in the Home Premium, Professional, Ultimate, and Enterprise editions of Windows 7. The following screen shows Sticky Notes is even handier in Windows 7.



NOTES

Using Sticky Notes

You can use Sticky Notes to write a to-do list, jot down a phone number, or do anything else that you'd use a pad of paper for. You can use Sticky Notes with a tablet pen or a standard keyboard. To write a note using a tablet pen, simply start writing on the note where you want the ink to appear. To type a note, click where you want the text to appear, and then start typing.

To create a new sticky note

- Open Sticky Notes by tapping the Start button . In the search box, type **Sticky Notes**, and then tap Sticky Notes in the list of results.
- To create additional notes, click the New Note button.
- You can also open a new note by pressing Ctrl+N.

Note: To resize a note, drag an edge or corner of the note to make it larger or smaller.

To delete a sticky note

When you have finished using a note, you can delete it to clean up your desktop.

- Click the Delete Note button.
- In the Sticky Notes dialog box, click Yes.
- You can also delete a note by pressing Ctrl+D.

Notes

- Sticky Notes closes if you delete all of your notes. To create a new note, reopen Sticky Notes.
- Open Sticky Notes by tapping the Start button . In the search box, type **Sticky Notes**, and then tap Sticky Notes in the list of results.

To change the color of a sticky note

- Right-click the note that you want to change, and then click a color.

To format text in a sticky note

You can format text, add bullets to make a list, or change the text size by using keyboard shortcuts. Here's how:

- Select the text that you want to change.
- Use the following keyboard shortcuts to format the text on your note:

NOTES

Type of Formatting	Keyboard Shortcut
Bold text	Ctrl+B
Italic text	Ctrl+I
Underlined text	Ctrl+U
Strikethrough	Ctrl+T
Bulleted list	Ctrl+Shift+L (Press this keybo ard shortcut again to switch to a numbered list.)
Increased text size	Ctrl+Shift+>
Decreased text size	Ctrl+Shift+<

9.6.4 Windows 7 Accessories

The following are the accessories that are available in Windows 7.

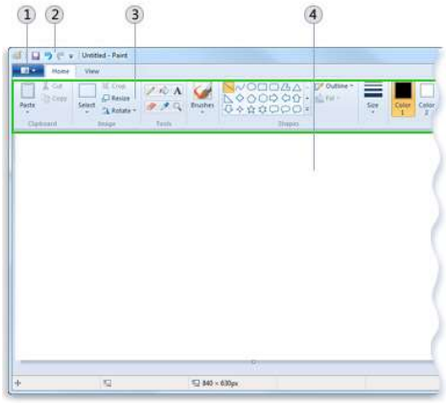
Paint

The new realistic digital 'brushes' help you to modify your pictures using shades of watercolor, crayon and calligraphy. A new ribbon, the strip across the top of the window shows what a program can do displays choices out in the open rather than in menus.

Using Paint

Paint is a feature in Windows 7 that you can use to create drawings on a blank drawing area or in existing pictures. Many of the tools you use in Paint are found in the ribbon, which is near the top of the Paint window. The following illustration shows the ribbon and other parts of Paint Window.

NOTES



1 Paint button
2 Quick Access Toolbar
3 Ribbon
4 Drawing area

Drawing Lines

- Open Paint by clicking the Start button, clicking All Programs, clicking Accessories, and then clicking Paint.

You can use several different tools to draw in Paint. The tool you use and the options you select determine how the line appears in your drawing. These are the tools you can use to draw lines in Paint.

Pencil Tool

Use the **Pencil** tool to draw thin, free-form lines or curves.

- On the Home tab, in the Tools group, click the Pencil tool.
- In the Colors group, click Color 1, click a color, and then drag the pointer in the picture to draw.
- To draw using the Color 2 (background) color, right-click while you drag the pointer.

Brushes

Use the **Brushes** tool to draw lines that have a different appearance and texture—it's like using different artistic brushes. By using different brushes, you can draw free-form and curving lines that have different effects.

- On the Home tab, click the down arrow under Brushes.
- Click the artistic brush that you want to use.
- Click Size, and then click a line size, which determines the thickness of the brush stroke.

In the Colors group, click Color 1, click a color, and then drag the pointer to paint.

- To paint using the Color 2 (background) color, right-click while you drag the pointer.

NOTES

Line tool

Use the **Line** tool to draw a straight line. When using this tool, you can choose the thickness of the line, as well as the appearance of it.

- On the Home tab, in the Shapes group, click the Line tool .
- Click Size, and then click a line size, which determines the thickness of the line.
- In the Colors group, click Color 1, click a color, and then drag the pointer to draw the line.
- To draw a line that uses the Color 2 (background) color, right-click while you drag the pointer. Optionally, to change the line style, in the Shapes group, click Outline and then click a line style.

Notes

- To draw a horizontal line, press and hold the Shift key as you draw from one side to the other.
- To draw a vertical line, press and hold the Shift key and draw up or down.

Curve Tool

Use the **Curve** tool to draw a smooth, curved line.

- On the Home tab, in the Shapes group, click the Curve tool .
- Click Size, and then click a line size, which determine the thickness of the line.
- In the Colors group, click Color 1, click a color, and then drag the pointer to draw the line.
- To draw a line that uses the Color 2 (background) color, right-click while you drag the pointer.
- After you have created the line, click the area in the picture where you want the arc of the curve to be, and then drag the pointer to adjust the curve.

Drawing Different Shapes

You can use Paint to add different shapes in a picture. The ready-made shapes range from traditional shapes—rectangles, ellipses, triangles, and arrows—to fun and unusual shapes, such as a heart, lightning bolt, or callouts. If you want to make your own custom shape, you can use to the Polygon tool to do this. The following are the Shapes available in Paint.

NOTES

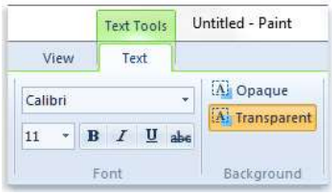
Polygon Tool

Use the **Polygon** tool to make a custom shape with any number of sides.

- On the Home tab, in the Shapes group, click the Polygon tool .
- To draw a polygon, drag the pointer to draw a straight line. Then, click each point where you want additional sides to appear.
- To create sides with 45- or 90-degree angles, press and hold the Shift key as you create each sides.
- Connect the last line to the first line to finish drawing the polygon and to close the shape.
- With the shape still selected, you can do one or more of the following if you want to change the appearance of it:
    - To change the line style, in the Shapes group, click Outline, and then click a line style.
    - If you don't want your shape to have an outline, click Outline, and then click No outline.
    - To change the outline size, click Size, and then click a line size (thickness).
    - In the Colors group, click Color 1, and then click a color for the outline.
    - In the Colors group, click Color 2, and then click a color to fill the shape.
    - To change the fill style, in the Shapes group, click Fill, and then click a fill style.
    - If you don't want your shape to be filled, click Fill, and then click No fill.

Adding Text

In Paint, you can also add your own text or message in your picture.



Text Tool

Use the **Text** tool to enter text in the picture.

- On the Home tab, in the Tools group, click the Text tool .
- Drag the pointer in the drawing area where you want to add text.

NOTES

- Under Text Tools, on the Text tab, in the Font group, click the font face, size, and style.
- In the Colors group, click Color 1, and then click a color for the text.
- Type the text that you want to add.

Select Tool

Use the **Select** tool to select part of the picture that you want to change.

- On the Home tab, in the Image group, click the down arrow under Select.
- Do one of the following, depending on what you want to select.
    - To select any square or rectangular part of the picture, click Rectangular selection, and then drag the pointer to select the part of the picture you want to work with.
    - To select any irregularly shaped part of the picture, click Free-form selection, and then drag the pointer to select the part of the picture you want to work with.
    - To select the whole picture, click Select all.
    - To select everything in the picture except for the currently selected area, click Invert selection.
    - To delete the selected object, click Delete.
- Determine if the Color 2 (background) color is included in your selection by doing the following:
    1. To include the background color with your selection, clear Transparent selection. When you paste the selection, the background color is included and will appear in the pasted item.
    2. To make the selection transparent so no background color is in the selection, click Transparent selection. When you paste the selection, any areas using the current background color will be transparent, which will allow the rest of the picture to appear in its place.

Crop

Use **Crop** to crop a picture so only the part you selected appears in your picture. Cropping lets you change the picture so only the selected object or person is visible.

- On the Home tab, in the Image group, click the arrow under Select, and then click the kind of selection you want to make.
- Drag the pointer to select the part of the picture you want to show.
- In the Image group, click Crop.

NOTES

- To save the cropped picture as a new file, click the Paint button , point to Save as, and then click the file type for the current picture.
- In the File name box, type a new file name, and then click Save.
- Saving the cropped image as a new picture file prevents overwriting the original picture file.

Rotate

Use **Rotate** to rotate the whole picture or a selected part of it.

- Depending on what you want to rotate, do one of the following:
  - o To rotate the whole picture, on the Home tab, in the Image group, click Rotate, and then click the rotation direction.
  - o To rotate an object or part of a picture, on the Home tab, in the Image group, click Select. Drag the pointer to select the area or object, click Rotate, and then click the rotation direction.

Erasing part of a picture:

Use the **Eraser** tool to erase areas of your picture.

- On the Home tab, in the Tools group, click the Eraser .
- Click Size, click an eraser size, and then drag the eraser over the area of the picture that you want to erase. Any areas that you erase will reveal the background color (Color 2).

Resizing a picture or part of it

Use **Resize** to resize the whole image or to resize an object or part of a picture. You can also skew an object in the picture so that it appears slanted.

Resize the whole picture

1. On the Home tab, in the Image group, click Resize.
2. In the Resize and Skew dialog box, select the Maintain aspect ratio check box so that the resized picture will have the same aspect ratio as the original.
3. In the Resize area, click Pixels, and then enter a new width in the Horizontal box or new height in the Vertical box. Click OK.

If the Maintain aspect ratio check box is selected, you only need to enter the horizontal value (width) or vertical value (height). The other box in the Resize area is updated automatically.

For example, if a picture is 320 x 240 pixels and you want to make it half that size with the same aspect ratio, in the Resize area, with the Maintain aspect ratio check box selected, enter 160 in the Horizontal box. The new picture size will be half the original size at 160 x 120 pixels.

NOTES

Working with Color

There are a number of tools to help you work specifically with color in Paint. They let you use the colors you want when you're drawing and editing in Paint.

Color Boxes

The **Color boxes** indicate the current **Color 1 (foreground color)** and **Color 2 (background color)** colors. How they're used depends on what you're doing in Paint.

When using the color boxes, you can do one or more of the following:

- To change the selected foreground color, on the Home tab, in the Colors group, click Color 1, and then click a color square.
- To change the selected background color, on the Home tab, in the Colors group, click Color 2, and then click a color square.
- To paint with the selected foreground color, drag the pointer.
- To paint with the selected background color, right-click while you drag the pointer.

Color Picker

Use the **Color picker** tool to set the current foreground or background color. By picking a color from the picture, you can make sure that you're using the color you want when drawing in Paint, so your colors match.

- On the Home tab, in the Tools group, click Color picker .
- Click the color in your picture that you want to set as the foreground color, or right-click the color in your picture that you want to set as the background color.

Fill with Color

Use the **Fill with color** tool to fill the entire picture or an enclosed shape with color.

- On the Home tab, in the Tools group, click Fill with color .
- In the Colors group, click Color 1, click a color, and then click inside the area to fill it.
- To remove the color and replace it with the background color instead, click Color 2, click a color, and then right-click the area to fill it.

NOTES

Editing Colors

Use **Edit colors** to pick a new color. Mixing colors in Paint lets you choose the exact color that you want to use.

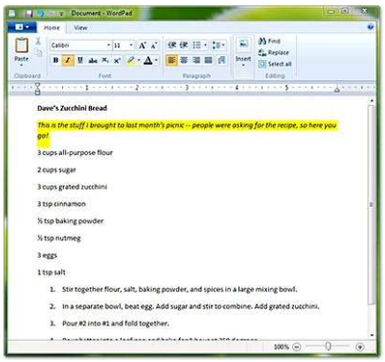
- On the Home tab, in the Colors group, click Edit colors.
- In the Edit Colors dialog box, click a color in the color pallette, and then click OK.

The color will appear in one of the color boxes, so you can use that color in Paint.

WordPad

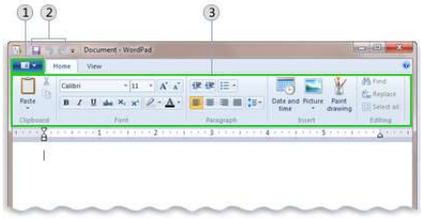
WordPad, always handy for basic word-processing, just got better. In Windows 7, it has a new ribbon—the strip across the top of the window that shows what a program can do—with choices displayed out in the open rather than in menus.

More formatting options, such as highlighting, bullets, line breaks, and new colors—along with picture insertion and zoom—make WordPad a surprisingly powerful tool.



Using WordPad

WordPad is a text-editing program you can use to create and edit documents. Unlike Notepad, WordPad documents can include rich formatting and graphics, and you can link to or embed objects, such as pictures or other documents. The following screen shows the WordPad window.



1 The WordPad button 2 Quick Access toolbar
3 The Ribbon

NOTES

Create, Open and Save Documents

- Open WordPad by clicking the Start button . In the search box, type **WordPad**, and then, in the list of results, click WordPad.
- Use the following commands to create, open, or save documents:

To	Do this
Create a new document	Click the WordPad menu button , and then click New.
Open a document	Click the WordPad menu button , and then click Open.
Save a document	Click the WordPad menu button , and then click Save.
Save a document with a new name or format	Click the WordPad menu button , point to Save as, and then click the format you want to save the document in.

Note: WordPad can be used to open and save text documents (.txt), rich text files (.rtf), Word documents (.docx), and OpenDocument Text (.odt) documents. Documents in other formats are opened as plain text documents and might not appear as expected.

Work Faster in WordPad

There's a quick way to put the commands you use most often in WordPad within easy reach—put them on the Quick Access Toolbar above the ribbon.

To add a WordPad command to the Quick Access Toolbar, right-click a button or command, and then click Add to Quick Access Toolbar.

Format Documents

Formatting refers to how the text in your document looks as well as how it's arranged. You can use the **ribbon**, located just underneath the title bar to easily change the formatting in your document. For example, you can choose from many different fonts and font sizes, and you can make your text almost any color you want. You can also easily change how your document is aligned.

- Open WordPad by clicking the Start button . In the search box, type **WordPad**, and then, in the list of results, click WordPad.

NOTES

- Use the following commands to change the formatting of your document:

To	Do this
Change how text looks in your document	Select the text that you want to change, and then use the buttons on the Home tab in the Font group. For more information about what each button does, hover over the button for a description.
Change how text is aligned in your document	Select the text that you want to change, and then use the buttons on the Home tab in the Paragraph group. For more information about what each button does, hover over the button for a description.

Insert Dates and Pictures to Documents

- Open WordPad by clicking the Start button . In the search box, type **WordPad**, and then, in the list of results, click WordPad.
- Use the following commands to insert the current date or a picture:

To	Do this
Insert the current date	1. On the Home tab, in the Insert group, click Date and time.
	2. Click the format you want, and then click OK.
Insert a picture	3. On the Home tab, in the Insert group, click Picture.
	4. Locate the picture that you want to insert, and then click Open.
Insert a drawing	5. On the Home tab, in the Insert group, click Paint drawing.
	6. Create the drawing that you want to insert and then close Paint.

NOTES

View Documents

- Open WordPad by clicking the Start button . In the search box, type **WordPad**, and then, in the list of results, click WordPad.
- Use the following commands to view documents:

To	Do this
Increase or decrease the zoom level	On the View tab, in the Zoom group, click Zoom in or Zoom out.
View the document at its actual size	On the View tab, in the Zoom group, click 100%.
Display the ruler	On the View tab, in the Show or hide group, select the Ruler check box.
Display the status bar	On the View tab, in the Show or hide group, select the Status bar check box.
Change the word wrap settings	On the View tab, in the Settings group, click Word wrap, and then click the setting that you want.
Change the unit of measurement on the ruler	On the View tab, in the Settings group, click Measurement units, and then click the units that you want.

Note: To zoom in and out in a document, you can also click the Zoom in or Zoom out buttons on the Zoom slider in the lower-right corner of the window to increase or decrease the zoom level.

Change Page Margins

- Open WordPad by clicking the Start button . In the search box, type **WordPad**, and then, in the list of results, click WordPad.
- Click the WordPad menu button , click Page setup, and then select the options you want.

Print Documents

- Open WordPad by clicking the Start button . In the search box, type **WordPad**, and then, in the list of results, click WordPad.
- Click the WordPad menu button , click Print, and then select the options you want.

Note: You can use Print preview to see how your document will look before you print it. To use Print preview, click the WordPad menu button , point to Print, and then click Print preview. When you are finished previewing your document, click Close print preview.

NOTES

Calculator

In Windows 7, Calculator has a fresh look and new features, including new Programmer and Statistics modes. Unit conversion translates Celsius to Fahrenheit, ounces to grams, and joules to BTUs. Handy calculation templates can help you compute stuff like fuel economy and auto lease payments. Calculator can do a lot more than arithmetic.

Using Calculator in Windows 7

You can use Calculator to perform simple calculations such as addition, subtraction, multiplication, and division. Calculator also offers the advanced capabilities of a programming, scientific, and statistical calculator.

You can perform calculations by clicking the calculator buttons, or you can type calculations by using your keyboard. You can also use the numeric keypad to type numbers and operators by pressing Num Lock.

Calculator Window

1. Open Calculator by clicking the Start button . In the search box, type **Calculator**, and then, in the list of results, click Calculator.
2. Click the View menu, and then click the mode that you want.

   When you switch modes, the current calculation is cleared. Calculation history and numbers stored by the memory keys are retained.
3. Click the calculator keys to perform the calculation you want.

Using Scientific Mode

1. Click the View menu, and then click Scientific.
2. Click the calculator keys to perform the calculation you want.

To access inverse functions, click the Inv key.

Notes

- In Scientific mode, Calculator is precise to 32 significant digits.
- Calculator honors operator precedence when calculating in Scientific mode.

NOTES

Using Programmer Mode

1. Click the View menu, and then click Programmer.
2. Click the calculator keys to perform the calculation you want.

Notes

- In Programmer mode, Calculator is precise up to 64 bits, depending on the word size that you've selected.
- Calculator honors operator precedence when calculating in Programmer mode.
- Programmer mode is an integer only mode. Decimal portions are discarded.

Using Statistics Mode

When you use Statistics mode, you can enter the data that you want to calculate statistics for and then perform the calculations. When you enter the data, it's displayed in the history area and the number of values you have entered is displayed in the calculation area.

1. Click the View menu, and then click Statistics.
2. Type or click your first piece of data, and then click Add to add the data to the dataset.
3. Click the button for the statistical calculation you want to perform:

Button	Function
$\bar{x}$	Average of the values
	Average of the square of the values
$\sum x$	Sum of the values
	Sum of the square of the values
σ_n	Standard deviation
	Standard deviation of population

Using Calculation History

Calculation history keeps track of all the calculations that Calculator performs in a session and is available in Standard and Scientific modes. You can change the values in the calculations in your history. While you're editing the calculation history, the result of the selected calculation is displayed in the result area.

1. Click the View menu, and then click History.
2. Double-click the calculation that you want to edit.
3. Enter the new values that you want to calculate, and then press Enter.

Note: Calculation history is kept separately for Standard and Scientific modes. The history that's displayed depends on the mode that you're using.

NOTES

Convert Values from One Unit of Measurement to Another

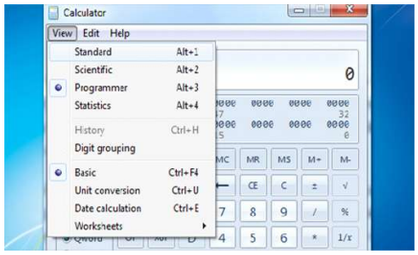
You can use Calculator to perform conversions for different units of measure.

1. Click the View menu, and then click Unit conversion.
2. Under Select the type of unit you want to convert, click the three lists to select the types of units you want to convert, and then, in the From box, enter the value that you want to convert.

Calculate Dates

You can use Calculator to calculate the difference between two dates or to add or subtract days from a specified date.

1. Click the View menu, and then click Date calculation.
2. Under Select the date calculation you want, click the list and select the type of calculation that you want to perform.
3. Enter the information, and then click Calculate.



Snipping Tool

Snipping Tool captures a screen shot of anything on your desktop, like a picture or a section of webpage. Snip a whole window, a rectangular section of the screen, or draw a freehand outline with your mouse or tablet pen (or your finger, if you are using a PC with a touchscreen). Then you can annotate, save, or e-mail the image using buttons right in the Snipping Tool window. Snipping Tool is available only in the Home Premium, Professional, and Ultimate editions of Windows 7.

Use Snipping Tool to Capture Screenshots: You can use Snipping Tool to capture a screen shot, or snip, of any object on your screen, and then annotate, save, or share the image.

You can capture any of the following types of snips:

- Free-form Snip. Draw a free-form shape around an object.
- Rectangular Snip. Drag the cursor around an object to form a rectangle.
- Window Snip. Select a window, such as a browser window or dialog box, that you want to capture.
- Full-screen Snip. Capture the entire screen.

After you capture a snip, it's automatically copied to the Clipboard and the mark-up window. From the mark-up window, you can annotate, save, or share the snip. The following procedures explain how to use Snipping Tool.

NOTES

System Restore

Ever wish you could turn back the clock after a bad crash? With Windows, you can.

Sometimes installing a program or driver can make Windows run slowly or unpredictably. System Restore can return your PC's system files and programs to a time when everything was working fine, potentially preventing hours of troubleshooting headaches. It won't affect your documents, pictures, or other data.

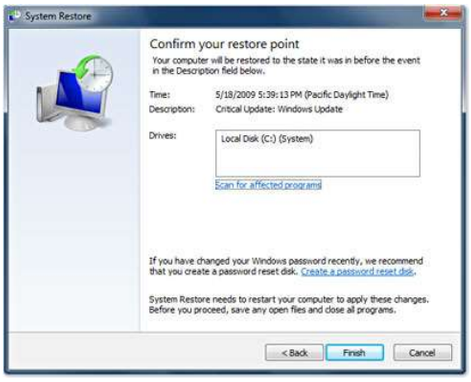
In Windows 7, you can create more system restore points and see exactly what files will be removed or added when your PC is restored.

For more protection, use System Restore with Backup and Restore, which is designed to help safeguard email, pictures, documents, and other personal files.

To Use System Restore

Before you start System Restore, save any open files and close all programs. System Restore will restart your PC.

1. Open System Restore by clicking the Start button . In the search box, type **System Restore**, and then, in the list of results, click System Restore. If you're prompted for an administrator password or confirmation, type the password or provide confirmation.
2. Follow the steps in the wizard to choose a restore point and restore your computer.



System Restore in Windows 7 can prevent hours of troubleshooting headaches after a crash.

NOTES

Windows Firewall

A firewall is like locking the front door to your house—it helps keep intruders (in this case, hackers and malicious software) from getting in. Windows Firewall is on by default in Windows 7, so you don't need to set it up—plus we've made it more flexible and easier to use.

Now you can fine-tune the protection and notifications you want for each of your network profiles—Home, Work, and Public. When you're connected to a public network like a library or a coffee shop, you may want to block all incoming connections. At home or work, this might be overkill. Whatever level of protection you choose for your profiles, you'll be able to switch between them with ease.

Windows Firewall can tailor protection for different network environments.

Windows Search

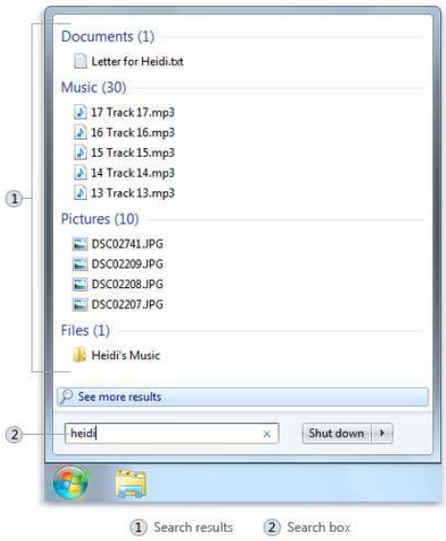
In Windows 7, you can find required documents, e-mail messages and songs. Start typing in the Start menu search box, and you will instantly see a list of relevant files on your PC. You can search by typing the name of the file, or based on its tags, file type, and even contents. To see even more matches, click a category in the results, like **Documents** or **Pictures**, or click **See more results**. Your search terms are highlighted to make it easier to scan the list.

Few people store all their files in one place these days. So Windows 7 is also designed to search external hard drives, networked PCs, and **libraries**. Overwhelmed by your search results? You can instantly narrow them by date, file type, and other useful categories.

Find a File or Folder

Windows provides several ways to find files and folders. There isn't one best way to search—you can use different methods for different situations.

NOTES



Use the Search Box on the Start Menu

You can use the search box on the Start menu to find files, folders, programs, and e mail messages stored on your computer.

To find an item using the Start menu:

• Click the Start button , and then type a word or part of a word in the search box.

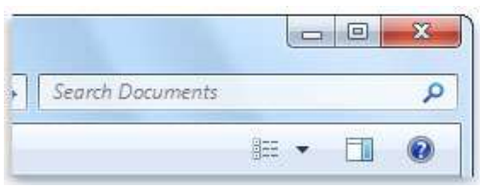
Search results appear as soon as you start typing in the search box.

As you type, items that match your text will appear on the Start menu. The search results are based on text in the file name, text in the file, tags, and other file properties.

Note: When searching from the Start menu, only files that have been indexed will appear in search results. Most files on your computer are indexed automatically. For example, anything you include in a library is automatically indexed.

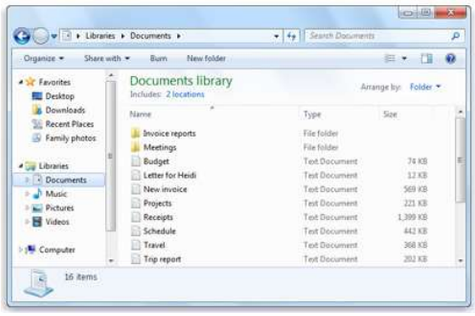
Use the Search Box in a Folder or Library

You may look for a file that you know is in a particular folder or library, such as Documents or Pictures. Browsing for the file might mean looking through hundreds of files and subfolders. To save time and effort, use the search box at the top of the open window. The following screen shows the search box in a folder or library.



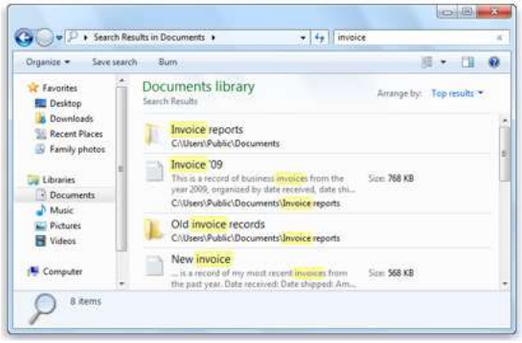
NOTES

The search box filters the current view based on text that you type. The search looks for text in the file name and contents; and in the file properties, such as in tags. In a library, the search includes all folders included in the library as well as subfolders within those folders.



To search for a file or folder by using the search box:

- Type a word or part of a word in the search box.
- As you type, the contents of the folder or library are filtered to reflect each successive character you type. When you see the file that you want, stop typing.



For example, suppose your Documents library looks like this:

The above screen shows a Documents library before typing in the search box. Now, suppose that you're looking for your invoice files, so you type "invoice" in the search box. As you type, the view is automatically filtered and you see something like this:

The above screen shows Documents library after typing "invoice" in the search box.

You can also use other techniques in the search box to quickly narrow down a search. For example, if you're searching for a file based on one or more if its properties (such as a tag or the date the file was last modified), you can use **search filters** to specify the property in your search. Or, you can type keywords in the search box to narrow down your results even further.

NOTES

Expand a Search Beyond a Specific Library or Folder

If you can't find what you're looking for in a specific library or folder, you can expand the search to include different locations.

1. Type a word in the search box.
2. Scroll to the bottom of the list of search results. Under Search again in, do one of the following:
   - Click Libraries to search across every library.
   - Click Computer to search across your entire computer. This is the way to search for files that aren't indexed (such as system or program files). However, be aware that the search will be slower.
   - Click Custom to search specific locations.
   - Click Internet to search online, using your default Web browser and your default search provider.

Windows Troubleshooting

Can not print? Internet down? Windows Troubleshooting can automatically pinpoint and fix common problems so you don't have to.

The Troubleshooting section of Control Panel includes more than a dozen troubleshooters for problems with networking, Internet, audio and video, and program compatibility. Troubleshooters aren't designed to solve every issue, but they can often save you time and headaches.

Troubleshooters can also help head off trouble by providing basic scheduled maintenance, such as cleaning up temporary files or scanning your hard disk for errors. If something suspicious turns up, you'll get a notification in **Action Center**.

9.7 HOW TO INSTALL WINDOWS 7

This step-by-step guide demonstrates how to install Windows 7 Ultimate. The guide is similar for other versions of Windows 7 such as Home Premium.

The best way to install Windows 7 is to do a clean install. It is not difficult to perform a clean installation. Before you start the installation process I recommend that you check Windows 7 System Requirements list to ensure that your hardware is supported by Windows 7. If you don't have Windows 7 drivers for all your hardware, it is a good idea to download all the drivers from the hardware manufacturers Website and save all the necessary drivers on a CD-R or a USB drive before you start the installation.

NOTES

Windows 7 DVD is bootable. In order to boot from the DVD you need to set the boot sequence. Look for the boot sequence under your BIOS setup and make sure that the first boot device is set to CD-ROM/DVD-ROM.

Step 1 - Place Windows 7 DVD in your dvd-rom drive and start your PC. Windows 7 will start to boot up and you will get the following progress bar.

Step 2 - The next screen allows you to setup your language, time and currency format, keyboard or input method. Choose your required settings and click next to continue.

Step 3 - The next screen allows you to install or repair Windows 7. Since we are doing a clean install we will click on "install now".

Step 4 - Read the license terms and tick I accept license terms. Then click next to continue.

Step 5 - You will now be presented with two options. Upgrade or Custom (Advanced). Since we are doing a clean install we will select Custom (Advanced).

NOTES

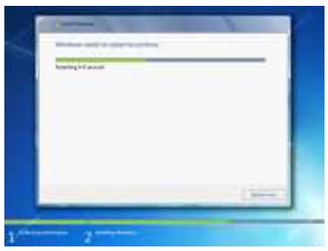
Step 6 - Choose where you would like to install Windows 7. If you have one hard drive you will get a similar option to the image below. You can click next to continue. If you have more that one drive or partition then you need to select the appropriate drive and click next. If you need to format or partition a drive then click Drive options (advance) before clicking next.

Step 7 - Windows 7 starts the installation process and starts copying all the necessary files to your hard drive as shown on the image below.

Step 8 - It will go through various stages of the setup and will reboot your system few times.

Step 9 - When your PC reboots it attempts to boot from DVD as its the first boot device. Do not press any key during the boot prompt so Windows 7 will continue with the installation by booting from the hard drive.

Step 10 - After the reboot your computer will be prepared for first use.



Step 11 - At this stage you need to choose a user name and computer name. Click next to continue. The user account you create here is the Administrator account which is the main account for your Windows 7 that has all the privileges.

NOTES

Step 12 - Choose your password and password hint just incase you forget your password and need to jog your memory.

Step 13 - You can now type the product key that came with Windows 7 and click next. If you do not enter the product key you can still proceed to the next stage. However Windows 7 will run in trial mode for 30 days. You must therefore activate Windows within 30 days otherwise you can not access your computer after 30 days.

Step 14 - Help protect your computer and improve Windows automatically. Choose Use recommended settings.

Step 15 - Review your time and date settings. Select your time zone, correct the date and time and click next to continue.

Step 16 - Select your computer's current location. If you are a home user then choose Home network otherwise select the appropriate option.

Step 17 - Windows will now finalize the settings for your computer and restart.

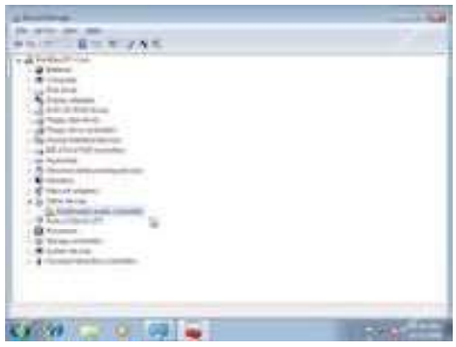
Step 18 - After the final restart Windows 7 will start to boot up.

Step 19 - Finally you have the logon screen. Just type your password and press enter or click on the arrow to logon to Windows 7 for the first time.

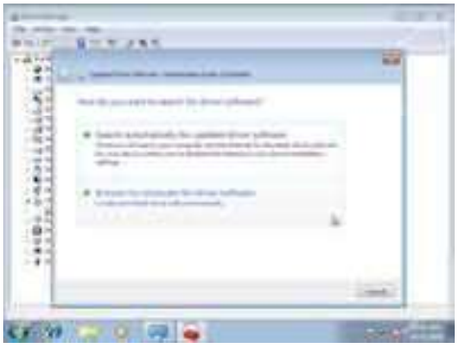
NOTES

Step 20 - After you have logged on to Windows 7 for the first time, you will see similar desktop to the image below. At this point you can start using your computer. However it may not be fully configured. You need to make sure that all the hardware is detected correctly and the necessary device drivers are installed. This can be done from the device manager.

Step 21 - To go to device manager click - ***Start Menu → Control Panel → System and Security → System → Device Manager***. You will see all your hardware listed as shown on the image below. You need to check if you have any yellow exclamation marks next to the name of the devices, similar to "Multimedia Audio Controller" on the image below. This indicates that the driver has not been installed for this device.



At this stage you can install the driver for this device. To do so, *Right Mouse click on* ***Multimedia Audio Controller → Update Driver Software...***

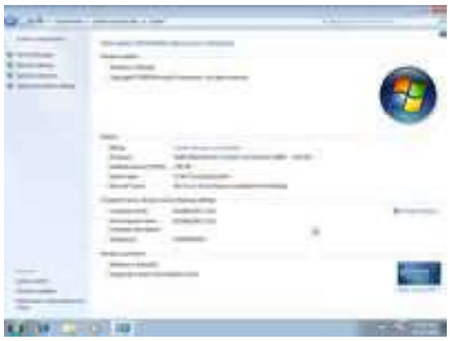


Step 22 - You can choose to "Search automatically for updated driver software" or "Browse my computer for driver software". If you have the driver CD or if the driver is on a USB drive then choose "browse my computer for driver software". Window 7 will search and install the driver from the CD or you can locate the driver manually.

Once you have removed all the yellow exclamation marks from the device manager your Windows 7 configuration would be fully complete.

Step 23 - Finally check if you have successfully activated Windows 7. Click ***Start Menu → Control Panel → System and Security → System***. You

will get a window similar to the image below. Towards the bottom you will see Windows is activated followed by your product ID. This shows that your copy of Windows 7 is fully activated.



NOTES

Check Your Progress

9. What is the role of a calculator in Windows 7?
10. Define the term snipping tool.
11. State the significance of firewall in Windows 7.
12. Why there is a troubleshooting section in Windows 7?

9.8 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Microsoft has included the unique features in Windows 7, such as multi-touch support, an updated Windows shell with a new taskbar, referred to internally as the Superbar, a home networking system called HomeGroup and performance improvements.
2. Magnifier zooms in on your desktop. Magnifier provides help to the users who have low vision.
3. The Aero desktop is available in the Home Premium, Professional, Ultimate and Enterprise editions of Windows 7. It mixes graphics with useful new ways to manage your desktop.
4. Windows 7 Home Premium edition contains features aimed at the home market segment, such as Windows Media Centre, Windows Aero and multitouch support.
5. Maximum limits on physical memory that Windows 7 can address vary depending on both the Windows version and between32-bit and 64-bit versions.
6. Jump Lists on the Start menu give you quick access to the things you use most often.

NOTES

7. Library gathers files from different locations and displays them as a single collection, without moving them from where they are stored.
8. The Remote Desktop Protocol (RDP) of Windows 7 is also enhanced to support real-time multimedia application including video playback and 3D games, thus allowing use of DirectX 10 in remote desktop environments.
9. In Windows 7, Calculator has a fresh look and new features, including new programmer and statistics modes. Unit conversion translates Celsius to Fahrenheit, ounces to grams.
10. Snipping tool captures a screen shot of anything on your desktop, like a picture or a section of Webpage.
11. A firewall is like locking the front door to your house—it helps keep intruders (in this case, hackers, and malicious software) from getting in. Windows Firewall is on by default in Windows 7, so you do not need to set it up—plus we have made it more flexible and easier to use.
12. The troubleshooting section of Control Panel includes more than a dozen trouble shooters for problems with networking, Internet, audio and video, and program compatibility.

9.9 SUMMARY

- Microsoft produced Windows 7 as an operating system to be used on personal computers (both home and business desktops0, laptops, netbooks, tablet PCs and media centre PCs.
- Windows 7 also supports images in RAW image format through the addition of Windows Imaging Component enabled image decoders, which enables raw image thumbnails, previewing and metadata display in Windows Explorer, plus full-size viewing and slideshows in Windows Photo Viewer and Windows Media Centre.
- Windows 7 has a range of accessibility features that help you to interact with your PC. It includes speech recognition and touch technology.
- Windows Speech Recognition has advanced features. Instead of using the keyboard, the user can instruct the computer what to do.
- Magnifier zooms in on your desktop. Magnifier provides help to the users who have low vision.
- Full screen mode magnifies the entire desktop and lens mode zooms the specified areas of the screen. Inside the Magnifier window, you can click buttons and input text normally.
- On-Screen Keyboard helps you to work without using a physically attached keyboard. Thus, it provides on-screen keyboard with an option of several different input methods, such as clicking mode, hovering mode, and scanning mode.

NOTES

- Windows 7 can read on-screen text aloud and can also describe some events, such as error messages. This feature helps the user to use the computer system when there is no display.
- Action center provides options to decide which Windows 7 alerts you want to see and which you do not. Action Center consolidates alerts from key Windows maintenance and security features, including Windows Error Reporting, Windows Defender and User Account Control.
- The Aero desktop is available in the Home Premium, Professional, Ultimate and Enterprise editions of Windows 7. It mixes graphics with useful new ways to manage your desktop.
- Aero visual hallmarks include subtle animations and translucent glass windows, which you can personalize. Using Aero, when you point to a taskbar button, you will see that a thumbnail-sized preview appears even for live video.
- Using BitLocker drive encryption, you can protect your data from loss, theft, or hackers. This feature is made advanced and improved for Windows 7 and is available in the Ultimate and Enterprise editions.
- Windows 7 is available in six different editions, of which the Home Premium, Professional and Ultimate editions are available for retail sale to consumers in most countries.
- Windows 7 Starter is the edition of Windows 7 that contains the fewest features. It is only available in a 32-bit version and does not include the Windows Aero theme.
- Windows 7 Home Basic is available in 'emerging markets', in 141 different countries. Some Windows Aero options are excluded along with several new features.
- Windows 7 Home Premium: This edition contains features aimed at the home market segment, such as Windows Media Center, Windows Aero and multitouch support.
- Windows 7 Home Premium edition contains features aimed at the home market segment, such as Windows Media Center, Windows Aero and multitouch support.
- Windows 7 Enterprise: This edition targets the enterprise segment of the market and is sold through volume licensing to companies which have a Software Assurance contract with Microsoft.
- The Start menu is a user interface element used in Microsoft Windows operating systems. It provides a central launching point for application and tasks. Depending on the operating system or window manager, the menu might have different names.
- The Start menu is essentially a blank slate that you can organize and customize to suit your preferences.

NOTES

- Windows 7 introduces Jump Lists for both the Start menu and the taskbar.
- Jump lists are lists of recent items, such as files, folders, or websites, organized by the program you use to open them.
- The Start menu includes a search box that you can use to find files, folders, programs, and e-mail messages stored on your computer.
- The Start button is located on the taskbar. Although you cannot remove the Start button from the taskbar, you can move the taskbar and the Start button along with it.
- The Aero desktop experience features a translucent glass design with subtle window animations and new window colors.
- The Aero desktop experience features glass-like windows for an open look. It includes distinctive visual styles that combine the appearance of lightweight, translucent windows with powerful graphic advances.
- Jump Lists are lists of recently or frequently opened items, such as files, folders, tasks, or Websites, organized by the program that you use to open them.
- Action Center is a single area that collects important notification messages about security and maintenance settings.
- Snipping tool captures a screen shot of anything on your desktop, like a picture or a section of Webpage.
- A firewall is like locking the front door to your house—it helps keep intruders (in this case, hackers, and malicious software) from getting in. Windows Firewall is on by default in Windows 7, so you do not need to set it up—plus we've made it more flexible and easier to use.

9.10 KEY WORDS

- **Magnifier:** Magnifier zooms in on your desktop. Magnifier provides help to the users who have low vision.
- **On-screen keyboard:** On-screen keyboard helps you to work without using a physically attached keyboard.
- **Action centre:** Action centre notifies the user whenever items must be modified. It also helps keep Windows running smoothly.
- **Aero desktop:** The Aero desktop is available in the home premium, professional, ultimate and enterprise editions of Windows 7. It mixes graphics with useful new ways to manage your desktop.
- **BitLocker drive encryption:** Using BitLocker drive encryption, you can protect your data from loss, theft, or hackers.

- **Windows 7 starter:** Windows 7 starter is the edition of Windows 7 that contains the fewest features. It is only available in a 32-bit version and does not include the Windows Aero theme.
- **Windows 7 home basic:** Windows 7 home basic is available in 'emerging markets', in 141 different countries. Some Windows Aero options are excluded along with several new features.
- **Windows 7 enterprise:** This edition targets the enterprise segment of the market and is sold through volume licensing to companies which have a software assurance contract with Microsoft.
- **Windows 7 ultimate:** Windows 7 Ultimate contains the same features as Windows 7 Enterprise, but unlike the enterprise edition, it is available to home users on an individual license basis.
- **N and KN editions:** The features in the N and KN Editions are the same as their equivalent full versions, but do not include Windows Media Player or other Windows media related technologies, such as Windows Media Centre and Windows DVD Maker.
- **Volume license keys:** It can be used to activate multiple installations of the software without any mechanism (such as, a product activation mechanism) checking the total number of installations.
- **Start menu:** It is a user interface element used in Microsoft Windows operating systems. It provides a central launching point for application and tasks.

9.11 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is Windows 7?
2. Define the term on screen keyboard.
3. Explain the characteristics of Windows 7.
4. How is starter edition different from Windows 7 home basic?
5. Define the term VL Builds.
6. List the methods to upgrade to Windows 7 from an earlier version of Windows.
7. What is physical memory in Windows 7?
8. What is the significance of jump list?
9. How can you work with jump lists on the taskbar?
10. Name all the power button options in Windows 7.

11. How can you customize the start menu?
12. How can you add the Run command to the start menu?

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Long-Answer Questions

1. Describe the significance of Windows 7 and list its all new features.
2. Elaborate on the editions of Windows using suitable examples.
3. What are the super purpose editions? Explain in brief giving suitable examples.
4. Discuss the standard hardware requirements for Windows 7 giving suitable examples.
5. Describe all the components of Windows 7 giving suitable examples.
6. Explain how you can make items on the screen appear bigger using magnifier using an example.
7. Elaborate on Windows 7 presentation style giving few examples.
8. How can you create HomeGroup in Windows 7? Elaborate with an example.
9. Describe the process of installation of Windows 7 giving step by step examples.

9.12 FURTHER READINGS

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UNIT 10 HUMAN COMPUTER INTERFACE

NOTES

Structure

10.0 Introduction
10.1 Objectives
10.2 Understand the Business Function
10.3 Business Definition and Requirement Analysis
10.4 Determining Business Functions
10.5 Design Standards or Style Guides
10.5.1 Document Design
10.6 Answers to Check Your Progress Questions
10.7 Summary
10.8 Key Words
10.9 Self Assessment Questions and Exercises
10.10 Further Readings

10.0 INTRODUCTION

A business process, business method or business function is a collection of related, structured activities or tasks by people or equipment in which a specific sequence produces a service or product for a particular customer or customers. Business processes occur at all organizational levels and may or may not be visible to the customers. A business process may often be visualized as a flowchart of a sequence of activities with interleaving decision points or as a process matrix of a sequence of activities with relevance rules based on data in the process. The benefits of using business processes include improved customer satisfaction and improved agility for reacting to rapid market change. Process-oriented organizations break down the barriers of structural departments and try to avoid functional silos.

Business analysis as a discipline includes requirements analysis, sometimes also called requirements engineering. It focuses on ensuring the changes made to an organisation are aligned with its strategic goals. Business requirements are often listed in a Business Requirements Document or BRD. The emphasis in a BRD is on process or activity of accurately accessing planning and development of the requirements, rather than on how to achieve it; this is usually delegated to a Systems Requirements Specification or Document (SRS or SRD), or other variation such as a Functional Specification Document. Confusion can arise between a BRD and an SRD when the distinction between business requirements and system requirements is disregarded. Consequently, many BRDs describe requirements of a product, system, or software.

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Document design is the process of choosing how to present all the basic document elements, so your document's message is clear and effective. When a document is well designed, readers understand the information more quickly and easily.

In this unit, you will study about the business functions, components of business functions, requirement analysis of a business process, direct and indirect methods, conceptual models, design standard or style guides and document design.

10.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of business functions
- Interpret the components of a business process
- Discuss the various requirement analysis of a business process
- Understand the importance of direct and indirect methods
- Learn about the conceptual models
- Know about the various design standard or style guides
- Discuss about the features of document design

10.2 UNDERSTAND THE BUSINESS FUNCTION

A business function is also defined as any set of activities performed by the department that is initiated by an event, transform information, materials or business commitments, and procedures an output (e.g., order fulfilment, invoicing, cash management, manufactured batch, customer response tracking, regulatory submissions, etc). A business process, business method or business function is a collection of related, structured activities or tasks by people or equipment in which a specific sequence produces a service or product serves a particular business goal for a particular customer or customers. Business processes occur at all organizational levels and may or may not be visible to the customers. A business process may often be visualized modelled as a flowchart of a sequence of activities with interleaving decision points or as a process matrix of a sequence of activities with relevance rules based on data in the process. The benefits of using business processes include improved customer satisfaction and improved agility for reacting to rapid market change. Process-oriented organizations break down the barriers of structural departments and try to avoid functional silos.

A business process begins with a mission objective an external event and ends with achievement of the business objective of providing a result that provides customer value. Additionally, a process may be divided into subprocesses, process decomposition, the inner functions of the process. Business processes may also

have a process owner, a responsible party for ensuring the process runs smoothly from start to finish.

Broadly speaking, business processes can be organized into three types:

1. Operational processes, which constitute the core business and create the primary value stream, e.g., taking orders from customers, opening an account, and manufacturing a component.
2. Management processes, the processes that oversee operational processes, including corporate governance, budgetary oversight, and employee oversight.
3. Supporting processes, which support the core operational processes, e.g., accounting, recruitment, call centre, technical support, and safety training.

A slightly different approach to these three types is offered by Kirchmer:

1. Operational processes, which focus on properly executing the operational tasks of an entity; this is where personnel get the things done.
2. Management processes, which ensure that the operational processes are conducted appropriately; this is where managers ensure efficient and effective work processes.
3. Governance processes, which ensure the entity is operating in full compliance with necessary legal regulations, guidelines, and shareholder expectations; this is where executives ensure the rules and guidelines for business success are followed.

A complex business process may be decomposed into several subprocesses, which have their own attributes but also contribute to achieving the overall goal of the business. The analysis of business processes typically includes the mapping or modelling of processes and sub-processes down to activity/task level. Processes can be modelled through many methods and techniques. For instance, the business process modelling notation is a business process modelling technique that can be used for drawing business processes in a visualized workflow. While decomposing processes into process types and categories can be useful, care must be taken in doing so as there may be crossover. In the end, all processes are part of a largely unified outcome, one of customer value creation. This goal is expedited with business process management, which aims to analyse, improve, and enact business processes.

10.3 BUSINESS DEFINITION AND REQUIREMENT ANALYSIS

Business is the activity of making one's living or making money by producing or buying and selling products (,such as goods and services) need quotation to verify. Having a business name does not separate the business entity from the owner,

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which means that the owner of the business is responsible and liable for debts incurred by the business. If the business acquires debts, the creditors can go after the owner's personal possessions. A business structure does not allow for corporate tax rates. The proprietor is personally taxed on all income from the business.

The term is also often used colloquially but not by lawyers or by public officials to refer to a company. A company, on the other hand, is a separate legal entity and provides for limited liability, as well as corporate tax rates. A company structure is more complicated and expensive to set up but offers more protection and benefits for the owner. Business requirements should inform every investment in new software and technological infrastructure. You do not launch a new project, purchase a new piece of enterprise software, or develop a new process unless it is in response to a core business need. Below requirement need to be taken care of:

1. Direct methods
2. Indirect methods
3. Requirement's collection guidelines

1. Direct Methods

The advantages of direct methods are they provide to hear the user's comments in person and first-hand. Secondly, person-to-person interactions allow for multiple channels of communication (body language, voice inflections, and so on) as well as the immediate follow-up on ambiguous or incomplete information.

Here are some recommended direct methods for getting input from users.

- Individual Face-to-Face Interview
- Telephone Interview or Survey
- Traditional Focus Group
- Facilitated Team Workshop
- Observational Field Study
- Requirements Prototyping
- User-Interface Prototyping
- Usability Laboratory Testing
- Card Sorting for Websites

Card Sorting for Websites

A technique to establish groupings of information for Websites.

Individual Face-to-Face Interview

It is a method where one-on-one visit with the user is conducted to collect information. Such interviews may be either structured or open ended. However, a formal questionnaire should not be used. In an interview, useful topics to ask the user to explain include:

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- The activities performed in completing a task or achieving a goal or objective.
- The methods used to perform an activity.
- What interactions exist with other people or systems?

It is also a good idea to look for some potential device usability metrics. It also aids in the identification of unmentioned exceptions to regular policies or procedures. A personal interview has many advantages, including the ability to give the user your undivided attention, the ability to easily include follow-up questions to obtain more details, the ability to explore subjects in greater depth, and the ability to gain a better understanding of your customers, their experiences, behaviours, values, and desires. However, there are some disadvantages also. Interviews have the disadvantage of being expensive and time-consuming to execute, and they should be conducted by someone experienced in interviewing techniques.

Telephone Interview or Survey

A structured interview conducted via telephone and had various advantages. The user should plan for the interview by scheduling it ahead of time, and these interviews are less costly and intrusive than personal interviews. They can be used much more regularly and are particularly useful for highly precise details.

Though there are many disadvantages also of the telephone interview contextual knowledge, such as a description of the working environment, is difficult to obtain, responses are easily affected by the interviewer's remarks and body language cues are absent. It may also be difficult to reach the appropriate person for the phone interview.

Traditional Focus Group

A small group of users and a moderator were gathered to address the criteria orally. A focus group is used to elicit information about users' perceptions, behaviours, values, and preferences, as well as their responses to ideas or prototypes. Setting up focus group involves the following:

- Establish the objectives of the session.
- Select participants representing typical users, or potential users. It is necessary to write a script for the moderator to follow.
- Find a skilled moderator to facilitate discussion, to ensure that the discussion remains focused on relevant topics, and to ensure that everyone participates.
- Allow the moderator flexibility in using the script.
- Take good notes, using the session recording for backup and clarification.

Facilitated Team Workshop

A facilitated, organised workshop with users to gather knowledge on specifications. The traditional focus group facilitated team workshop, like the traditional focus group facilitated team workshop, takes a long time to plan and run.

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Observational Field Study

Users study and track for an extended period to understand what they do in this process. These observations provide valuable information about the activities being carried out, the working climate and conditions, the social environment, and working practises. This technique can be time consuming and costly at times, but it is extremely beneficial in understanding the market.

2. Indirect Methods

An indirect method of requirements determination is one that places an intermediary between the developer and the user. This intermediary may be electronic or another person. There are many problems associated with the indirect methods. There may be deliberate or accidental filtering or distortion of the message. The intermediary may also lack a full or current understanding of the user's needs, resulting in the transmission of an incomplete or incorrect message. There are various ways to uncover the information under indirect methods:

- MIS or Management Information Systems Intermediary
- Paper Surveyor Questionnaire
- Electronic Surveyor Questionnaire
- Electronic Focus Group
- Marketing and Sales
- Support Line
- EMail or Bulletin Board
- User Group
- Competitor Analyses
- Trade Show
- Other Media Analysis
- System Testing

MIS Intermediary

To designers and developers, a company representative describes the user's goals and needs. This representative may be from the information services department or from the department that will be using the information.

Paper Survey or Questionnaire

To obtain their needs, a survey or questionnaire is sent to a sample of users using traditional mail methods. There are many advantages of paper survey over the MIS intermediary. Questionnaires can reach a broad target audience in almost every location and are much less expensive than customer visits. They do, however, have a poor return rate in general. The main problem is it takes a long time to collect questionnaire and may be difficult to analyse as well. There is another problem with the questionnaires are people do not take interest in filling the questionnaire.

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During the survey it is important to take care of questionnaire should be composed mostly of closed questions and it should be relatively short and created by someone experienced in their design.

Electronic Survey or Questionnaire

To obtain their needs, a survey or questionnaire is sent to a sample of users using traditional mail methods. In creating an electronic survey, it is important the understand the following things:

- One must determine the survey objectives.
- Need to be clear from where to conduct the survey also known as the target people.
- Make a combination of multiple choice and open-ended questions with brief responses that address the survey's goals.
- Maintain a short questionnaire that takes no more than 5–10 minutes to complete.

Iterative survey

Consider conducting a follow-up, more in-depth survey, or surveys, referred to as iterative surveys. If those who completed and returned the initial survey are willing to answer more specific questions, ask them. If that is the case, make and submit a more comprehensive survey. A third follow-up survey can be created to collect more information about the most relevant criteria and tasks. Iterative surveys, on the other hand, take longer to complete.

Electronic Focus Group

A small group of users and a moderator discuss the requirements online using workstations. The advantages electronic focus group over traditional focus groups are that the discussion is less influenced by group dynamics; has a smaller chance of being dominated by one or a few participants; can be anonymous, leading to more honest comments and less caution in proposing new ideas. The disadvantages of electronic focus group are the depth and richness of verbal discussions does not exist and the communication enhancement aspects of seeing participant's body language are missing.

Marketing and Sales

Customer's feedback and wishes, both existing and future, are obtained by company representatives who consult with them on a regular basis.

Support Line

The data gathered by the unit that assists consumers with day-to-day issues is analysed (customer support, technical support, help desk, etc.).

E-Mail or Bulletin Board

User's problems, questions, and suggestions are analysed after they are posted on a bulletin board or sent via e-mail.

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User Group

Improvements are suggested by customer groups who convene periodically to discuss software usage. They require careful planning.

Competitor Analyses

To collect ideas, discover design criteria, and define activities, an analysis of competitor's products or Web pages is used.

Trade Show

Customers are shown a mock-up or prototype at a trade show and asked for feedback.

Other Media Analysis

An examination of how the method, material, or subject matter of interest is presented in other media, such as print or broadcast.

System Testing

Continuous product testing yields new specifications and feedback.

Check Your Progress

1. Where does a business process occur?
2. List the categories in which a business process can be organized.
3. Define the term indirect method.
4. What is the role of card sorting for Websites?

10.4 DETERMINING BUSINESS FUNCTIONS

A concise overview of the product's capabilities is being written. The major system functions, as well as essential system inputs and outputs are identified and explained. A flowchart of major functions is developed. The process the developer will use is summarized as follows:

- Developing conceptual modes
- Understanding mental models
- Users new mental model

Developing Conceptual Modes

The designer creates a conceptual model for the user interface because of the task review. The general conceptual structure in which the system's functions are described is known as a conceptual model. A model like this explains how the interface will present objects, their relationships, their properties, and the actions that will be taken.

The designer's aim is to make it easier for the consumer to create a useful mental model of the system. This is achieved by providing the consumer with a

useful device called conceptual model. When the user meets the system, his or her current mental model can, ideally, fit well with the conceptual model of the system.

There are few guidelines for designing the conceptual models:

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1. ***Draw physical analogies or present metaphors:*** Replicate what is well-known and common. Duplicate acts that are well-understood. To be accurate, a metaphor must be widely applicable within an interface.
2. ***Comply with expectancies, habits, routines, and stereotypes:*** Avoid new and unfamiliar associations by using existing ones. Accepted definitions for red, yellow, and green, for example, are also well known. Use words and phrases in their traditional contexts.
3. ***It should eflect the user's mental model :*** A user's preferences and experience levels can vary from those of the designer. As a result, the user's and designer's conceptual models can vary. The consumer is concerned with the job at hand, as well as the business goals that must be met.
4. ***Provide action response compatibility:*** All responses from the system should be consistent with the behaviour that elicited them. Command names, for example, should represent the acts that will be performed.
5. ***Invisible to visible:*** It makes the make invisible parts and process of a system visible. New users of a system often make incorrect or incomplete assumptions about what is hidden, resulting in a flawed mental model. As they gain more knowledge, their mental models become more reliable and complete. The process of constructing accurate mental models would be accelerated by making unseen parts of a system visible.
6. ***Feedback:*** Be generous in providing feedback. It is important to get the proper and correct feedback. Keep a person informed of what is happening, and what has happened, always. Provide visible results of action, such as shows the actions in progress and helps in providing a continuous indication of status. Feedback helps in getting the present as much context information as possible with constructive, clear, and correct error messages.
7. ***Promote the development of both Beginners and expert mental models:*** It helps in promoting the development of both beginners and expert mental models. Beginners and experts are likely to bring to bear different mental models when using a system.
8. ***Avoid anything unnecessary or irrelevant:*** Never display irrelevant information on the screen. People may try to interpret it and integrate it into their mental models, thereby creating a false one.

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9. ***Provide documentation to conceptual model:*** Provide documentation and a help system that will reinforce the conceptual model. Do not depend on people to find consistency and metaphors on their own. The assistance framework should provide guidance on how to improve mental models.
10. ***Provide design consistency:*** Consistency in design decreases the number of principles that must be taught. To master inconsistency, you must master several models. If an occasional inconsistency is unavoidable, inform the consumer.
11. ***Understanding the user's mental model:*** Gaining a picture of the user's mental model is one of the goals of task analysis and knowing the user. An internal reflection of a person's current conceptualization and perception of something is referred to as a mental model.

To understand, explain, and do something, mental models are gradually created. If the actions required to complete a task have been overlooked or have not yet been experienced, an individual may use mental models to predict the actions required.

10.5 DESIGN STANDARDS OR STYLE GUIDES

A design standard, also known as a style guide, is a set of guidelines for how to do something. It also lays out the interface specifications, regulations, guidelines, and conventions that must be adhered to during the thorough design process.

- Value of standards and guidelines
- Document design
- Design support and implementation

Value of standards and guidelines

Design quality is achieved by developing and implementing design specifications or guidelines. Design standards and guidelines helps the designers to design the application quickly and helps the end users in performing faster. Designers makes the less mistake during the design phase and improve the satisfaction level at the same time. Once application is designed, developed, and deployed, it takes very less time in providing the training as throughout the application design remains the same.

Some benefits of standards and guidelines are:

- Allow faster performance.
- Reduce errors.
- Reduce training time.
- Foster better system utilization.

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- Improve satisfaction.
- Improve system acceptance.

They are valuable to system developers because they

- Increase visibility of the human-computer interface.
- Simplify design.
- Provide more programming and design aids, reducing programming time.
- Reduce redundant effort.
- Reduce training time.
- Provide a benchmark for quality control testing.

10.5.1 Document Design

Designing a document include concrete examples of proper design and an explanation for why the specific guidelines should be followed. Checklists are also used to present standards and guidelines. This document provides a justification for different design alternatives and describes the circumstances under which they are acceptable.

Create the guideline document using well-known document design concepts. A comprehensive index, a table of contents, glossaries, and checklists are all included in the document.

Design support and implementation

- Use all available reference sources in creating the guidelines.
- Use development and implementation tools that support the guidelines.
- Begin applying the guidelines immediately.

System training and documentation

System training and documentation needs:

- System training
- Documentation

System training

User specifications, system conceptual design, system learning goals, and system success goals can all influence system training. Any potential problems can also be identified and addressed earlier in the design process, reducing later problems and modification costs.

Formal or video instruction, manuals, online videos, reference manuals, simple reference guides, and online help are all examples of training tools.

Documentation

System documentation serves as a point of reference, a means of communication, and a more concrete specification—words that can be seen and interpreted based

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on user specifications, system conceptual design, and system performance objectives. It is also going to be documenting the creation phase will expose problems and omissions that would otherwise go undetected until far later in the design process.

Check Your Progress

5. How can be the process of developers be summarized?
6. Why does the designer create a conceptual model?
7. How are the design standards useful?
8. What does the system training and documentation needs?

10.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Business processes occur at all organizational levels and may or may not be visible to the customers. A business process may often be visualized (modelled) as a flowchart of a sequence of activities with interleaving decision points or as a process matrix of a sequence of activities with relevance rules based on data in the process.
2. Business processes can be organized into three types:
   - Operational processes
   - Management processes
   - Supporting processes
3. An indirect method of requirements determination is one that places an intermediary between the developer and the user. This intermediary may be electronic or another person. There are many problems associated with the indirect methods.
4. A technique to establish groupings of information for Websites.
5. The process the developer will use is summarized as follows:
   - Developing conceptual modes
   - Understanding mental models
   - Users new mental model
6. The designer creates a conceptual model for the user interface because of the task review.
7. Design standards and guidelines helps the designers to design the application quickly and helps the end users in performing faster.

8. System training and documentation needs:
   - System training
   - Documentation

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10.7 SUMMARY

- A business function is also defined as any set of activities performed by the department that is initiated by an event, transform information, materials or business commitments, and procedures an output.
- A business process, business method or business function is a collection of related, structured activities or tasks by people or equipment in which a specific sequence produces a service or product.
- Business processes occur at all organizational levels and may or may not be visible to the customers.
- A business process begins with a mission objective an external event and ends with achievement of the business objective of providing a result that provides customer value.
- Operational processes, which constitute the core business and create the primary value stream, e.g., taking orders from customers, opening an account, and manufacturing a component.
- Management processes, the processes that oversee operational processes, including corporate governance, budgetary oversight, and employee oversight.
- Supporting processes, which support the core operational processes, e.g., accounting, recruitment, call centre, technical support, and safety training.
- Operational processes, which focus on properly executing the operational tasks of an entity; this is where personnel get the things done.
- Management processes, which ensure that the operational processes are conducted appropriately; this is where managers ensure efficient and effective work processes.
- Governance processes, which ensure the entity is operating in full compliance with necessary legal regulations, guidelines, and shareholder expectations; this is where executives ensure the rules and guidelines for business success are followed.
- A complex business process may be decomposed into several subprocesses, which have their own attributes but also contribute to achieving the overall goal of the business.

NOTES

- The analysis of business processes typically includes the mapping or modelling of processes and sub-processes down to activity/task level.
- Business is the activity of making one's living or making money by producing or buying and selling products (,such as goods and services) need quotation to verify.
- A business structure does not allow for corporate tax rates. The proprietor is personally taxed on all income from the business.
- Business requirements should inform every investment in new software and technological infrastructure.
- The advantages of direct methods are they provide to hear the user's comments in person and first-hand.
- A personal interview has many advantages, including the ability to give the user your undivided attention, the ability to easily include follow-up questions to obtain more details.
- Interviews have the disadvantage of being expensive and time-consuming to execute, and they should be conducted by someone experienced in interviewing techniques.
- A structured interview conducted via telephone and had various advantages. The user should plan for the interview by scheduling it ahead of time, and these interviews are less costly and intrusive than personal interviews.
- A facilitated, organised workshop with users to gather knowledge on specifications.
- An indirect method of requirements determination is one that places an intermediary between the developer and the user. This intermediary may be electronic or another person.
- Questionnaires can reach a broad target audience in almost every location and are much less expensive than customer visits. They do, however, have a poor return rate in general.
- The disadvantages of electronic focus group are the depth and richness of verbal discussions does not exist and the communication enhancement aspects of seeing participant's body language are missing.
- Customer's feedback and wishes, both existing and future, are obtained by company representatives who consult with them on a regular basis.
- The general conceptual structure in which the system's functions are described is known as a conceptual model.
- A design standard, also known as a style guide, is a set of guidelines for how to do something. It also lays out the interface specifications, regulations, guidelines, and conventions that must be adhered to during the thorough design process.

- Design quality is achieved by developing and implementing design specifications or guidelines.
- Design standards and guidelines helps the designers to design the application quickly and helps the end users in performing faster.
- Checklists are also used to present standards and guidelines. This document provides a justification for different design alternatives and describes the circumstances under which they are acceptable.
- User specifications, system conceptual design, system learning goals, and system success goals can all influence system training.
- System documentation serves as a point of reference, a means of communication, and a more concrete specification—words that can be seen and interpreted based on user specifications, system conceptual design, and system performance objectives.

10.8 KEY WORDS

- **Operational processes:** It constitute the core business and create the primary value stream, e.g., taking orders from customers, opening an account, and manufacturing a component.
- **Management processes:** The processes that oversee operational processes, including corporate governance, budgetary oversight, and employee oversight.
- **Card sorting for Websites:** Supporting processes, which support the core operational processes, e.g., accounting, recruitment, call centre, technical support, and safety training.
- **Individual face-to-face interview:** A technique to establish groupings of information for Websites.
- **An indirect method:** Its requirements determination is one that places an intermediary between the developer and the user. This intermediary may be electronic or another person.

10.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What is the need for design standards?
2. State the different types of users.
3. List the five design commandments.

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4. What are the direct methods in requirement analysis?
5. Define the term system training tools.
6. What are the indirect methods in requirement analysis?
7. What are the guidelines for designing conceptual model?
8. Why are the style guides important in design process?

Long-Answer Questions

1. What is a business process? Discuss the different categories of a business process.
2. Differentiate between direct and indirect methods giving suitable examples.
3. Discuss about business function giving appropriate examples.
4. State the importance of electronic survey or questionnaire. Give suitable examples.
5. Elaborate on user groups and discuss their role in business process.
6. What is document design? Discuss its various features.

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UNIT 11 SOFTWARE TOOLS SPECIFICATION METHODS

NOTES

Structure

11.0 Introduction
11.1 Objectives
11.2 Software Requirements Specification (SRS)
 11.2.1 Interface Building Tools
 11.2.2 Interface Mockup Tools
11.3 Windowing System Layer
 11.3.1 GUI Toolkit Layer
11.4 Answers to Check Your Progress Questions
11.5 Summary
11.6 Key Words
11.7 Self Assessment Questions and Exercises
11.8 Further Readings

11.0 INTRODUCTION

A programming tool or software development tool is a computer program that software developers use to create, debug, maintain, or otherwise support other programs and applications. Tools may be discrete programs, executed separately – often from the command line – or may be parts of a single large program, called an Integrated Development Environment (IDE). IDEs combine the features of many tools into one package. A specification often refers to a set of documented requirements to be satisfied by a quantifiable, design, product, or service. A specification is often a type of technical standard. There are different types of technical or engineering specifications (specs), and the term is used differently in different technical contexts.

A Software Requirements Specification (SRS) is a description of a software system to be developed. It is modelled after business requirements specification (CONOPS), also known as a Stakeholder Requirements Specification (StRS). A CONcept of OPerations (abbreviated CONOPS, CONOPs, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. CONOPS is used to communicate the quantitative and qualitative system characteristics to all stakeholders. CONOPS are widely used in the military, governmental services and other fields. The software requirements specification document lists sufficient and necessary requirements for the project development.

A software tool is a programmatic software used to create, maintain, or otherwise support other programs and applications. Specification methods are

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the unique methods used to specify the GUI (Graphical User Interface). Interface building tools are typical design methods that help in designing command languages, data-entry structures, and widgets. The interface mockup tools are specific tools used to develop a quick sketch of GUI, such as Microsoft Visio, Visual Studio .Net, etc.

User Interface (UI) design is the specific process that the software design engineers use for building interfaces in software or computerized devices, that typically focus on the appearance or style. The aim of the software designers is to create user-friendly interfaces so that the users can easily use the tools for completion of the task efficiently. User Interface (UI) design precisely refers to Graphical User Interfaces (GUIs) and other forms, for example voice-controlled interfaces.

A mockup is a conceptual tool that is used especially in web development. It is basically an early draft of a website or web application. Mockups are primarily used for conception to convert ideas and concepts into a concrete design. They typically include the final navigation structure and detailed design elements so that they often resemble the final design of the website.

In computing, a windowing system or window system is software that manages separately different parts of display screens. It is a type of Graphical User Interface (GUI) which implements the WIMP (Windows, Icons, Menus, Pointer) paradigm for a User Interface (UI). There are numerous widget toolkits, also known as GUI frameworks, used to construct the Graphical User Interface (GUI) of programs, organized by their relationships with various operating systems.

In this unit, you will study about the software tools specification methods, interface building tools, interface mockup tools, software engineering tools, windowing system layer and GUI toolkit layer.

11.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss about the software tools specification methods
- Understand why interface building tools are required
- Know about the interface mockup tools
- Explain about the software engineering tools
- Elaborate on the windowing system layer
- Define the importance of GUI toolkit layer

11.2 SOFTWARE REQUIREMENTS SPECIFICATION (SRS)

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A **S**oftware **R**equirements **S**pecification (**SRS**) is a description of a software system to be developed. It is modelled after business requirements specification (CONOPS), also known as a **St**akeholder **R**equirements Specification (**StRS**). A CONcept of OPerations (abbreviated CONOPS, CONOPs, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. CONOPS is used to communicate the quantitative and qualitative system characteristics to all stakeholders. CONOPS are widely used in the military, governmental services and other fields.

The software requirements specification lays out functional and non-functional requirements, and it may include a set of use cases that describe user interactions that the software must provide to the user for perfect interaction.

Software requirements specification establishes the basis for an agreement between customers and contractors or suppliers on how the software product should function (in a market-driven project, these roles may be played by the marketing and development divisions). Software requirements specification is a rigorous assessment of requirements before the more specific system design stages, and its goal is to reduce later redesign. It should also provide a realistic basis for estimating product costs, risks, and schedules. Used appropriately, software requirements specifications can help prevent software project failure.

The software requirements specification document lists sufficient and necessary requirements for the project development. To derive the requirements, the developer needs to have clear and thorough understanding of the products under development. This is achieved through detailed and continuous communications with the project team and customer throughout the software development process.

The SRS may be one of a contract's deliverable data item descriptions or have other forms of organizationally-mandated content.

Typically a SRS is written by a technical writer, a systems architect, or a software programmer.

Structure

An example organization of an SRS is as follows:

1. Purpose

(i) Definitions

(ii) Background

(iii) System Overview

(iv) References

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2. Overall Description

(i) Product Perspective
- System Interfaces
- User Interfaces
- Hardware Interfaces
- Software Interfaces
- Communication Interfaces
- Memory Constraints

(ii) Design Constraints
- Operations
- Site Adaptation Requirements

(iii) Product Functions

(iv) User Characteristics

(v) Constraints, Assumptions and Dependencies

3. Specific Requirements

(i) External Interface Requirements

(ii) Performance Requirements

(iii) Logical Database Requirement

(iv) Software System Attributes
- Reliability
- Availability
- Security
- Maintainability
- Portability

(v) Functional Requirements
- Functional Partitioning
- Functional Description
- Control Description

(vi) Environment Characteristics
- Hardware
- Peripherals
- Users

(vii) Other

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Goals

The Software Requirements Specification (SRS) is a communication tool between users and software designers. The specific goals of the SRS are as follows:

- Facilitating Reviews
- Describing the Scope of Work
- Providing a Reference to Software Designers, i.e., Navigation Aids, Document Structure
- Providing a Framework for Testing Primary and Secondary Use Cases
- Including Features to Customer Requirements
- Providing a Platform for Ongoing Refinement via Incomplete Specs or Questions

System Requirements Specification (SyRS)

A System Requirements Specification (SyRS), abbreviated as SysRS when need to be distinct from a Software Requirements Specification (SRS), is a structured collection of information that embodies the requirements of a system.

A Business Analyst (BA), sometimes termed as System Analyst (SA), is responsible for analysing the business requirements of their clients and stakeholders to help identify business problems and propose solutions. Within the systems development life cycle domain, the BA typically performs a liaison function between the business side of an enterprise and the information technology department or external service providers.

Software Tools

A software tool is a programmatic software used to create, maintain, or else support other programs and applications. Following are some of the commonly used software tools in Human Computer Interface (HCI):

Specification Methods: The specification methods are used to specify the Graphical User Interface (GUI). Even though the specification methods are lengthy and ambiguous methods, but they are easy to understand.

Grammars: Grammars are the written Instructions or Expressions that a program can understand. It provides authorisations for completeness and correctness.

Transition Diagram: Transition diagrams are set of nodes and links that can be displayed in text, link frequency, state diagram, etc. They are difficult in evaluating usability, visibility, modularity and synchronization.

State Charts: Chart methods are typically developed for simultaneous user activities and external actions. The charts provide link-specification with interface building tools.

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Interface Building Tools: Interface building tools are design methods that help in designing command languages, data-entry structures, and widgets.

Interface Mockup Tools: Interface Mockup tools are used to develop a quick sketch of GUI, for example Microsoft Visio, Visual Studio .Net, etc.

Software Engineering Tools: Software engineering tools are defined as the extensive programming tools that provide user interface management system.

Evaluation Tools: Evaluation tools are specific tools used to evaluate the correctness and completeness of programs.

11.2.1 Interface Building Tools

User Interface (UI) design is the specific process that the software design engineers use for building interfaces in software or computerized devices, that typically focus on the appearance or style. The aim of the software designers is to create user-friendly interfaces so that the users can easily use the tools for completion of the task efficiently. User Interface (UI) design precisely refers to Graphical User Interfaces (GUIs) and other forms, for example voice-controlled interfaces.

User Interface (UI) Design

User Interface (UI) Design focuses on anticipating what users might need to do and ensuring that the interface has elements that are easy to access, understand, and use to facilitate those actions. UI brings together concepts from interaction design, visual design, and information architecture.

Interface elements include the following:

- **Input Controls:** These include buttons, text fields, checkboxes, radio buttons, dropdown lists, list boxes, toggles, and date field.
- **Navigational Components:** These include breadcrumb, slider, search field, pagination, slider, tags, and icons.
- **Informational Components:** These include tooltips, icons, progress bar, notifications, message boxes, and modal windows.

Designing an Interface: The interface is designed after understanding the user's goals, skills, preferences, and requirements. After analysing the aims and requirements of the specific users, the following interfaces can be designed:

- Keep the interface simple. The best interfaces are almost invisible to the user. They avoid unnecessary elements and are clear in the language they use on labels and in messaging.
- Create consistency and use common UI elements. By using common elements in the UI, users feel more comfortable and are able to get things done more quickly. It is also important to create patterns in language, layout and design throughout the site to help facilitate efficiency. Once a user learns how to do something, they should be able to transfer that skill to other parts of the site.

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- Be purposeful in page layout. Consider the spatial relationships between items on the page and structure the page based on importance. Careful placement of items can help draw attention to the most important pieces of information and can aid scanning and readability.
- Strategically use color and texture. You can direct attention toward or redirect attention away from items using color, light, contrast, and texture to your advantage.
- Use typography to create hierarchy and clarity. Carefully consider how you use typeface. Different sizes, fonts, and arrangement of the text to help increase scanability, legibility and readability.
- Make sure that the system communicates what is happening. Always inform your users of location, actions, changes in state, or errors. The use of various UI elements to communicate status and, if necessary, next steps can reduce frustration for your user.
- Considering about the defaults. By carefully thinking about and anticipating the goals people bring to your site, you can create defaults that reduce the burden on the user. This becomes particularly important when it comes to form design where you might have an opportunity to have some fields pre-chosen or filled out.

Designing Specific User Interfaces (UIs) for Users

User Interfaces (UIs) are the access points where the users interact with designs. Specific User Interfaces (UIs) has the following three formats:

1. **Graphical User Interfaces (GUIs):** The Graphical User Interfaces (GUIs) are essential when the users interact with visual representations on digital control panels, for example a computer's desktop is a GUI.
2. **Voice-Controlled Interfaces (VUIs):** The Voice-Controlled Interfaces (VUIs) are essential when the users interact with these through their voices. Most smart assistants, for example Siri on iPhone and Alexa on Amazon devices are termed as VUIs.
3. **Gesture-Based Interfaces:** The Gesture-based interfaces are essential when the users engage with 3D design spaces through bodily motions, for example in Virtual Reality (VR) games.

For designing perfect and appropriate User Interfaces or UIs, consider the following points:

- User's judge designs quickly and should be alert about usability and likeability.
- The tasks must be done easily and with minimum effort.
- The design of UIs should predicts users' needs, so that they can have personalized and immersive experiences.
- UIs should communicate brand values and reinforce users' trust.

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Consequently, in the field of Human Computer Interaction (HCI), a User Interface (UI) is the space where interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the user's decision-making process. Examples of this broad concept of User Interfaces or UIs include the interactive aspects of computer operating systems, hand tools, heavy machinery operator controls, and process controls. Generally, the goal of User Interface or UI design is to produce a user interface which makes it easy, efficient, and enjoyable (user-friendly) to operate a machine in the way which produces the desired result (i.e., maximum usability). This generally means that the operator needs to provide minimal input to achieve the anticipated output, and also that the machine minimizes undesired outputs to the user.

User Interfaces or UIs are composed of one or more layers, including a Human Machine Interface (HMI) that interfaces machines with physical input hardware, such as keyboards, mice, or game pads, and output hardware, such as computer monitors, speakers, and printers. A device that implements an HMI is called a Human Interface Device (HID). Other terms for Human Machine Interfaces (HMIs) are Man-Machine Interface (MMI) and, when the machine in question is a computer, Human Computer Interface (HCI). Additional UI layers may interact with one or more human senses, including the tactile UI (touch), visual UI (sight), auditory UI (sound), olfactory UI (smell), equilibrial UI (balance), and gustatory UI (taste).

Composite User Interfaces (CUIs) are UIs that interact with two or more senses. The most common CUI is a Graphical User Interface (GUI), which is composed of a tactile UI and a visual UI capable of displaying graphics. When sound is added to a GUI, it becomes a Multimedia User Interface (MUI). There are three broad categories of CUI: Standard, Virtual and Augmented. Standard CUI use standard human interface devices, like keyboards, mice, and computer monitors. When the CUI blocks out the real world to create a virtual reality, the CUI is virtual and uses a virtual reality interface. When the CUI does not block out the real world and creates augmented reality, the CUI is augmented and uses an augmented reality interface. When a UI interacts with all human senses, it is called a Qualia Interface (QI), named after the 'Theory of Qualia'.

The engineering of Human Machine Interfaces (HMIs) is enhanced by considering 'Ergonomics' (human factors). The corresponding disciplines are Human Factors Engineering (HFE) and Usability Engineering (UE), which is part of systems engineering.

Multimodal interfaces allow users to interact using more than one modality of the user input.

11.2.2 Interface Mockup Tools

A mockup is a conceptual tool that is used especially in web development. It is basically an early draft of a website or web application. Mockups are primarily

used for conception to convert ideas and concepts into a concrete design. They typically include the final navigation structure and detailed design elements so that they often resemble the final design of the website.

Mockups range from simple templates without functionality to interactive prototype-like designs created with dedicated mockup software. Smaller projects often do not require the use of mockups. In such a case, the templates are created directly in HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) or finished templates are adjusted to individual requirements.

A mockup is a static wireframe that includes more stylistic and visual UI details to present a realistic model of how the final page or application will look.

Even though the terms wireframe, prototype, and mockup are often used as synonyms, but these are independent conceptual tools. There are three different design types or design stages that are performed before the actual programming.

A wireframe represents the earliest template version in web development and, in contrast to mockups, does not contain colors, textual (typography), or visual content (photos, graphics). This first rough concept can be either created on a computer using special wireframe software or can be drawn manually by hand. Since the wireframes are the first draft, hence they lack any functionality and therefore they are considered as low dependability concept drawings.

Mockups are typically based on an existing wireframe structure and represent the next stage of the interface design. By using textual and visual elements, a mockup can be very similar to the final product design. Even though the mockups were originally static, but now it is possible to create interactive mockups including simple functions, such as internal links by using modern mockup software. Depending on their complexity and scope, mockups are very close to a 'Prototype'.

Multi-layered, complex mockups serve as the basis for prototypes which, depending on their complexity, are counted as middle to high dependability concepts. Prototypes almost resemble the final product. In contrast to traditional, static mockups, prototypes are interactive and usually already contain all planned features of the website or application.

Application of Mockups

Recent web development process uses mockups during website or app development to present them to clients or a test audience as part of quality controls and demonstrations. These mockups often depict an app's or website final version in its full functionality, allowing an evaluation of previous development work. During this evaluation, the clients' and the users' ideas, requirements, and requests regarding the design, the User Interface (UI), the structure, and the scope of features can be incorporated and checked.

Benefits of Mockups

Mockups are used in web development because it has many advantages. Subsequently, the mockups can be created with reasonably little effort and it

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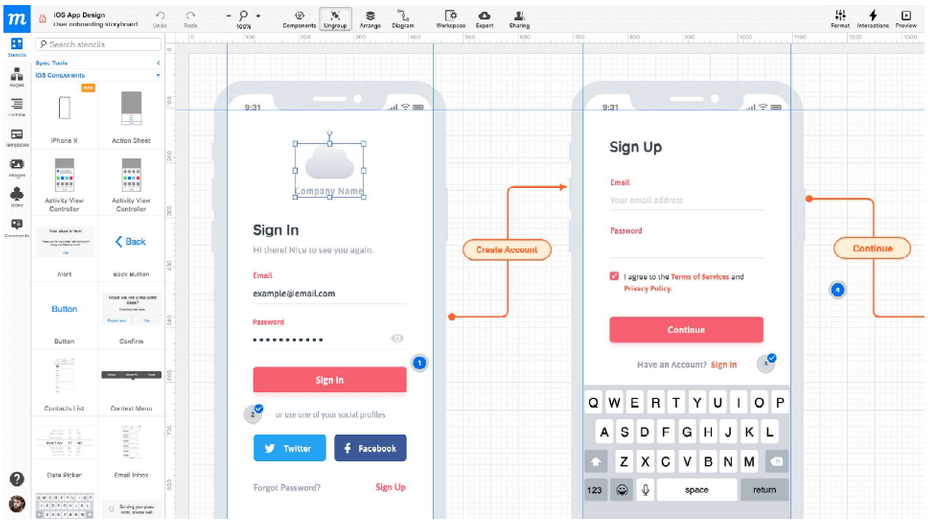
provides a realistic impression of the final product, so it can be used to test usability and identify potential errors and error sources before spending unnecessary time on the interface development. Problems can be identified before the creation of prototype and the risk of completely redesigning the product during the interface development can be minimized. Consequently, using mockups for web development saves a lot of money and time.

Mockup Tools

Presentation and image editing programs, such as Microsoft PowerPoint or Adobe Illustrator can be used to create simple user-friendly mockup tools. Compared to dedicated mockup software, however, these are relatively hard to use and provide less features. Dedicated mockup tools provide numerous template elements and the facility for creating modular mockup designs in addition to simple interaction sequences quickly and easily. Following screenshot illustrates an example of web app that helps you to create and collaborate in real-time on wireframes, mockups, diagrams and prototypes.



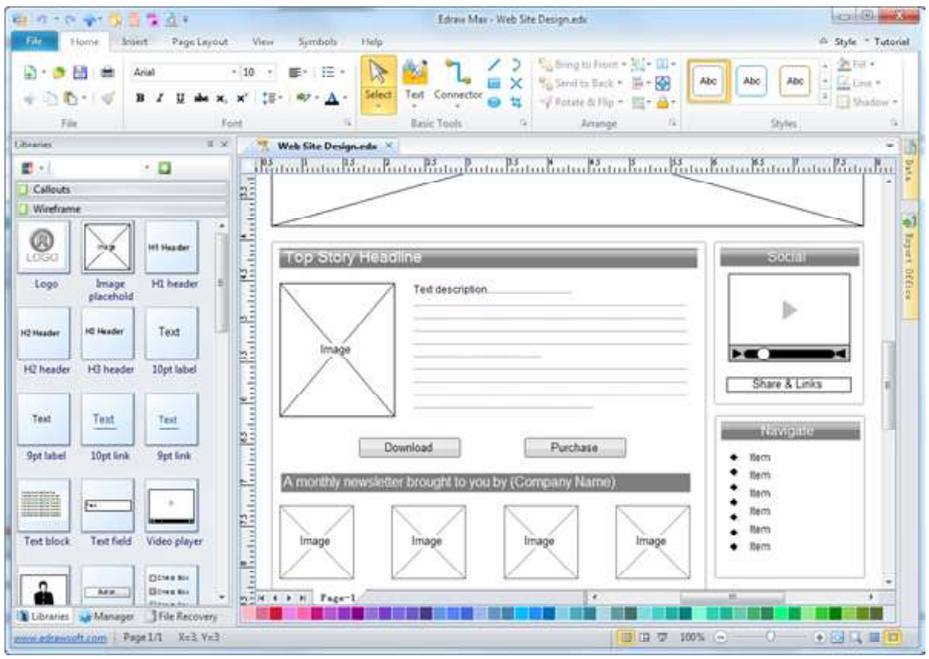
Wireframe Software - Edraw

Edraw can be used as an easy wireframe software for creating simple wireframes or working wireframe prototype.

A website wireframe, also known as a page schematic or screen blueprint, is a visual guide that represents the skeletal framework of a website. The wireframe depicts the page layout or arrangement of the website's content, including interface elements and navigational systems, and how they work together.

Wireframe Software Edraw: Edraw is the easy Wireframe Software used to create and share interactive wireframe diagrams. Whether you are designing

into a new windows UI, planning an iPhone interface or restructuring and rescheduling your website, Edraw provides the right tools for creating interactive diagrams. With Edraw you can recreate website UI, Mac UI, iPad UI and iPhone UI in just a few clicks to complete your required plans using thousands of ready-made symbols. Following screenshot illustrates the screen of Wireframe Software Edraw.



11.3 WINDOWING SYSTEM LAYER

In computing, a windowing system or window system is software that manages separately different parts of display screens. It is a type of Graphical User Interface (GUI) which implements the WIMP (Windows, Icons, Menus, Pointer) paradigm for a User Interface (UI).

Each currently running application is assigned a usually resizable and usually rectangular surface of the display to present its GUI to the user; these windows may overlap each other, as opposed to a tiling interface where they are not allowed to overlap. Usually a window decoration is drawn around each window. The programming of both the window decoration and of available widgets inside of the window, which are graphical elements for direct user interaction, such as sliders, buttons, etc., is eased and simplified through the use of widget toolkits.

Following Figure 11.1 illustrates the typical elements of a window. The window decoration is either drawn by the window manager or by the client. The drawing of the content is the task of the client.

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Fig. 11.1 *Typical Elements of a Window*

The main component of any windowing system is usually called the display server, although alternative denominations, such as window server or compositor are also in use. Any application that runs and presents its GUI in a window, is a client of the display server. The display server and its clients communicate with each other over a communications protocol, which is usually called display server protocol, the display server being the mediator between the clients and the user. It receives all the input from the kernel, that the kernel receives from all attached input devices, such as keyboard, pointing devices, or touchscreen and transmits it to the correct client. The display server is also responsible for the output of the clients to the computer monitor. The output of sound is usually not managed by the display server, but the sound volume is usually handled through GUI applets and it is the display server who decides which applications are on top. A windowing system enables the computer user to work with several programs at the same time. Each program presents its GUI in its own window, which is generally a rectangular area of the screen.

From a programmer's point of view, a windowing system implements graphical primitives. For example, rendering fonts or drawing a line on the screen. It provides an abstraction of the graphics hardware for use by higher-level elements of the graphical interface, such as a window manager.

A display server protocol can be network capable or even network transparent, facilitating the implementation of thin clients. In computer networking, a thin client is a simple (low-performance) computer that has been optimized for establishing a remote connection with a server-based computing environment. The server does most of the work, which can include launching software programs, performing calculations, and storing data. This contrasts with a fat client or a

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conventional personal computer; the former is also intended for working in a client–server model but has significant local processing power, while the latter aims to perform its function mostly locally.

Display Server

A display server or window server is a program whose primary task is to coordinate the input and output of its clients to and from the rest of the operating system, the hardware, and each other. The display server communicates with its clients over the display server protocol, a communications protocol, which can be network-transparent or simply network-capable.

The display server is a key component in any Graphical User Interface (GUI), specifically the windowing system.

Figure 11.2 illustrates the basic components of a Graphical User Interface (GUI), the display server implements the windowing system. A simple window manager merely draws the window decorations, but compositing window managers can do more.

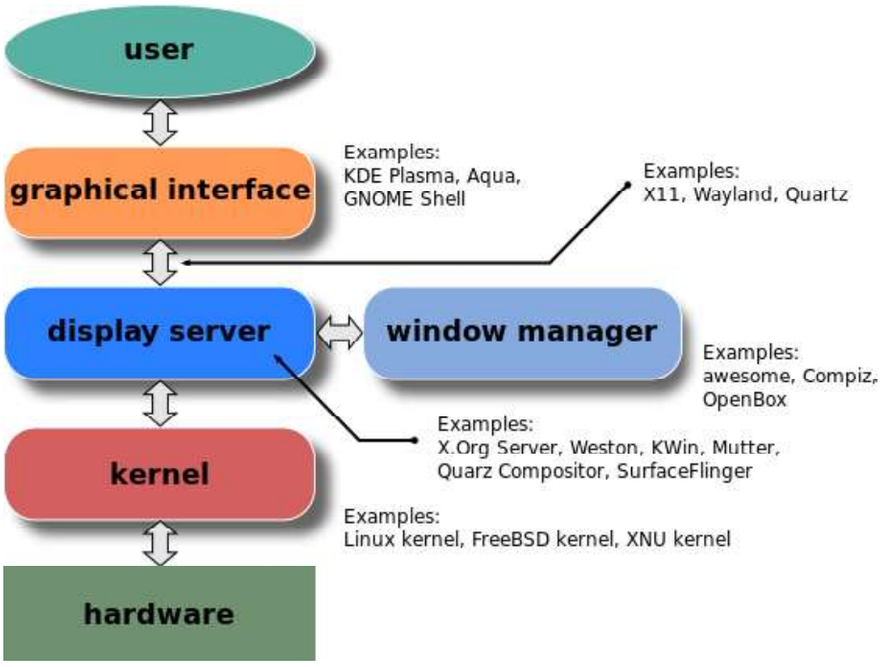

Fig. 11.2 *Basic Components of a Graphical User Interface (GUI)*

(Source: Wikipedia)

Display Server Communications Protocols

Following are the communications protocols for 'Display Server':

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X11 or X Window System: One example of a display server is the X.Org Server, which runs on top of the kernel (usually a UNIX-like kernel, such as Linux or BSD). It receives user input data (e.g., from evdev on Linux) and passes it to one of its clients. The display server also receives data from its clients; it processes the data, it does the compositing and on Linux it passes the data to one of three kernel components – DRM (Direct Rendering Manager), gem or KMS driver. The component writes the data into the framebuffer and content of the framebuffer is transmitted to the connected screen and displayed. X relies on GLX.

Wayland: Display servers that implement the Wayland display server protocol, are called Wayland compositors. Like any display server, a Wayland compositor is responsible for handling input and output for its clients and – in contrast to X11 – additionally for the compositing. Examples are Weston, Mutter, KWin or Enlightenment. Wayland compositors communicate with Wayland clients over the Wayland display server protocol. This protocol defines that clients can directly write data into the framebuffer using the EGL rendering API. The display server still gets to decide which window is on top and thus visible to the user and also still is responsible for passing data regarding to input devices from evdev to its clients.

Rendering API is a software library for submitting rendering commands, and managing render states and rendering resources; examples include OpenGL, Direct3D, Vulkan. Provides an abstraction layer for a graphics processing unit.

Mir: The Mir display server comes with its own Mir display server protocol which is different from those used by X11 and Wayland. Mir additionally supports the X11 protocol. It was developed by Canonical and was intended to be the display server of choice for Ubuntu. There are implementations of the Mir display server, the libmir-server and the libmir-client libraries available under the GPLv3.

SurfaceFlinger: Google developed a display server called 'SurfaceFlinger' for Android, another Linux kernel-based operating system primarily for mobile devices. Everything in Android is rendered to a 'Surface', typically the 'Surfaces' are produced by applications and placed into a queue that is managed by means of SurfaceFlinger. For compositing in Android, Surfaces are sent to SurfaceFlinger, which uses OpenGL ES to do the compositing. Hardware Composer HAL (HWC) was introduced in Android 3.0 and has evolved steadily over the years. Its primary purpose is to determine the most efficient way to composite buffers with the available hardware. As a HAL, its implementation is device-specific and usually done by the display hardware OEM.

Quartz Compositor: For Apple's macOS family of operating systems, Quartz Compositor fulfils the tasks of a display server and of a window manager in the windowing system.

Desktop Window Manager (DWM): For Microsoft Windows, from Windows Vista onward, Desktop Window Manager (DWM) enables the use of hardware acceleration to render the Graphical User Interface (GUI). It was originally created to enable portions of the new 'Windows Aero' user experience, which allowed for effects, such as transparency, 3D window switching and more. It is also included with Windows Server 2008, but requires the 'Desktop Experience' feature and compatible graphics drivers to be installed.

11.3.1 GUI Toolkit Layer

There are numerous widget toolkits, also known as GUI frameworks, used to construct the Graphical User Interface (GUI) of programs, organized by their relationships with various operating systems.

A. Low-Level Widget Toolkits

Following are the low-level widget toolkits:

1. Integrated in the Operating System (OS)

- OS X uses Cocoa. Mac OS9 and OS X use Carbon for 32-bit applications. Cocoa is Apple's native object-oriented Application Programming Interface (API) for its desktop operating system macOS. Carbon was one of two primary C-based Application Programming Interfaces (APIs) developed by Apple for the macOS operating system. Carbon provided a good degree of backward compatibility for programs that ran on Mac OS 8 and 9.
- The Windows API used in Microsoft Windows. Microsoft had the graphics functions integrated in the kernel until 2006. The Windows API, informally WinAPI, is Microsoft's core set of Application Programming Interfaces (APIs) available in the Microsoft Windows operating systems. The name Windows API collectively refers to several different platform implementations that are often referred to by their own names.
- The Haiku operating system uses an extended and modernised version of the Be API that was used by its spiritual predecessor BeOS. Haiku Inc. is expected to drop binary and source compatibility with the BeOS at some point in the future, which will result in its own Haiku API. Haiku is a free and open-source operating system compatible with the now discontinued BeOS. BeOS is an operating system for personal computers first developed by Be Inc. in 1990. It was first written to run on BeBox hardware. BeOS was positioned as a multimedia platform that could be used by a substantial population of desktop users and a competitor to Classic Mac OS and Microsoft Windows.

2. As a Separate Layer on Top of the Operating System (OS)

- The X Window System contains primitive building blocks, called Xt or 'Intrinsics', but they are mostly only used by older toolkits, such as OLIT,

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Motif and Xaw. The X Window System is a windowing system for bitmap displays, common on UNIX-like operating systems. X Toolkit Intrinsics is a library that implements an API to facilitate the development of programs with a Graphical User Interface (GUI) for the X Window System. It can be used in the C or C++ languages. X Athena Widgets or Xaw is a GUI widget library for the X Window System. Developed as part of Project Athena, Xaw was written under the auspices of the MIT X Consortium as a sample widget set built on X Toolkit Intrinsics (Xt); Xt and Xaw are collectively known as the X Toolkit. Most contemporary toolkits, such as GTK or Qt, bypass them and use Xlib or XCB directly.

- The Amiga OS Intuition was formerly present in the Amiga Kickstart ROM and integrated itself with a medium-high level widget library which invoked the Workbench Amiga native GUI. AmigaOS is a family of proprietary native operating systems of the Amiga and AmigaOne personal computers. It was developed first by Commodore International and introduced with the launch of the first Amiga, the Amiga 1000, in 1985. Since Amiga OS 2.0, Intuition.library became disk based and object oriented. Also Workbench.library and Icon.library became disk based, and could be replaced with similar third-party solutions.
- Since 2005, Microsoft has taken the graphics system out of Windows' kernel.

B. High-Level Widget Toolkits

Following are the high-level widget toolkits:

OS Dependent High-Level Widget Toolkits

1. On Amiga

- BOOPSI (Basic Object-Oriented Programming System for Intuition) was introduced with OS 2.0 and enhanced Intuition with a system of classes in which every class represents a single widget or describes an interface event. This led to an evolution in which third-party developers each realised their own personal systems of classes.
- MUI: Object-Oriented GUI toolkit and the official toolkit for MorphOS.
- ReAction: Object-Oriented GUI toolkit and the official toolkit for AmigaOS.
- Zune (GUI toolkit) is an open source clone of MUI and the official toolkit for AROS.

2. On Macintosh

- Cocoa - Used in OS X.
- MacApp Macintosh framework.
- PowerPlant Macintosh framework.

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3. On Microsoft Windows

- The Microsoft Foundation Classes (MFC), a C++ wrapper around the Windows API.
- The Windows Template Library (WTL), a template-based extension to ATL and a replacement of MFC.
- The Object Windows Library (OWL), Borland's alternative to MFC.
- The Visual Component Library (VCL) is Embarcadero's toolkit used in C++Builder and Delphi. It wraps the native Windows controls, providing object-oriented classes and visual design, although also allowing access to the underlying handles and other WinAPI details if required. It was originally implemented as a successor to OWL, skipping the OWL/MFC style of UI creation, which by the mid-nineties was a dated design model.
- Windows Forms is Microsoft's .NET set of classes that handle GUI controls. In the cross-platform Mono implementation, it is an independent toolkit, implemented entirely in managed code (not wrapping the Windows API, which does not exist on other platforms). WinForms' design closely mimics that of the VCL.
- The Windows Presentation Foundation is the graphical subsystem of the .NET Framework 3.0. User interfaces can be created in WPF using any of the CLR languages (e.g., C#) or with the XML-based language XAML. Microsoft Expression Blend is a visual GUI builder for WPF.

4. On UNIX, under the X Window System

Note that the X Window System was originally primarily for UNIX-like operating systems, but it now runs on Microsoft Windows as well using, for example, Cygwin, so some or all of these toolkits can also be used under Windows.

- LessTif, an open-source (LGPL) version of Motif.
- MoOLIT, a bridge between the look-and-feel of OPEN LOOK and Motif.
- Motif used in the Common Desktop Environment.
- OLIT, an Xt-based OPEN LOOK intrinsics toolkit.
- Xaw, the Project Athena widget set for the X Window System.
- XView, a SunView compatible OPEN LOOK toolkit.

Cross-Platform High-Level Widget Toolkits

1. Based on C (including Bindings to Other Languages)

- Elementary, open-source (LGPL), a part of the Enlightenment Foundation Libraries, a fast, stable, and scalable library that can be used to create both rich and fast applications that can be used on anything from every day desktop computers to small PDA's and set-top boxes.

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- GTK, open-source (LGPL), primarily for the X Window System, ported to and emulated under other platforms; used in the GNOME, Rox, LXDE and Xfce desktop environments. The Windows port has support for native widgets.
- IUP, open-source (MIT), a minimalist GUI toolkit in ANSI C for Windows, UNIX and Linux.
- Tk, open-source (BSD-style), a widget set accessed from Tcl and other high-level script languages (interfaced in Python as Tkinter).
- XForms, the Forms Library for X.
- XVT, Extensible Virtual Toolkit.

2. Based on C++ (including Bindings to Other Languages)

- CEGUI, open-source (MIT License), cross-platform widget toolkit designed for game development, but also usable for applications and tool development. Supports multiple renderers and optional libraries.
- FLTK, open-source (LGPL), cross-platform toolkit designed to be small and fast.
- FOX toolkit, open-source (LGPL), cross-platform toolkit.
- GLUI, a very small toolkit written with the GLUT library.
- gtkmm, C++ version of GTK.
- Juce provides GUI and widget set with the same look and feel in Microsoft Windows, X Window Systems, OS X and Android. Rendering can be based on OpenGL.
- Nana C++, open-source (Boost license), a cross-platform toolkit designed to enable modern C++ GUI programming.
- Qt, proprietary and open-source (GPL, LGPL) available under UNIX and Linux (with X11 or Wayland), MS Windows (Desktop, CE and Phone 8), OS X, iOS, Android, BlackBerry 10 and embedded Linux; used in the KDE, Trinity, LXQt, and Lumina desktop environment, it is also used in Ubuntu's Unity shell.
- Rogue Wave Views (formerly ILOG Views) provides GUI and graphic library for Windows and the main X11 platforms.
- TnFOX, open-source (LGPL), a portability toolkit.
- Ultimate++ is a free Win32/X11 application framework bundled with an IDE (BSD license).
- The Visual Component Framework (VCF) is an open-source (BSD license) C++ framework project.

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- wxWidgets (formerly wxWindows), open-source (relaxed LGPL), abstracts toolkits across several platforms for C++, Python, Perl, Ruby and Haskell.
- Zinc Application Framework, cross-platform widget toolkit.

3. Based on OpenGL

- Clutter (LGPL) (in C) is an open source software library for creating fast, visually rich and animated Graphical User Interfaces (GUIs).

4. Based on Flash

- Adobe Flash allows creating widgets running in most web browsers and in several mobile phones.
- Adobe Flex provides high-level widgets for building web user interfaces. Flash widgets can be used in Flex.
- Flash and Flex widgets will run without a web browser in the Adobe AIR runtime environment.

5. Based on Go

- Fyne, open-source (BSD) is inspired by the principles of Material Design to create applications that look and behave consistently across Windows, macOS, Linux, BSD, Android and iOS.

6. Based on XML

- GladeXML with GTK.
- XAML with Silverlight or Moonlight.
- XUL.

7. Resource-Based

- Google Web Toolkit (GWT).
- Pyjs.
- FBML Facebook Markup Language.

8. Based on SVG

- Raphaël is a JavaScript toolkit for SVG interfaces and animations.

9. Based on C#

- Gtk#, C# wrappers around the underlying GTK and GNOME libraries, written in C and available on Linux, MacOS and Windows.
- QtSharp, C# wrappers around the Qt widget toolkit, which is itself based-on the C++ language.
- Windows Forms. There is an original Microsoft's implementation that is a wrapper around the Windows API and runs on windows, and Mono's alternative implementation that is cross-platform.

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10. Based on Java

- The Abstract Window Toolkit (AWT) is Sun Microsystems' original widget toolkit for Java applications. It typically uses another toolkit on each platform on which it runs.
- Swing is a richer widget toolkit supported since J2SE 1.2 as a replacement for AWT widgets. Swing is a lightweight toolkit, meaning it does not rely on native widgets.
- Apache Pivot is an open-source platform for building rich web applications in Java or any JVM-compatible language, and relies on the WTK widget toolkit.
- JavaFX and FXML.
- The Standard Widget Toolkit (SWT) is a native widget toolkit for Java that was developed as part of the Eclipse project. SWT uses a standard toolkit for the running platform (such as, the Windows API, OS X Cocoa, or GTK) underneath.
- Codename One originally designed as a cross platform mobile toolkit it later expanded to support desktop applications both through JavaSE and via a JavaScript pipeline through browsers.
- Java-gnome provides bindings to the GTK toolkit and other libraries of the GNOME desktop environment.
- Qt Jambi, the official Java binding to Qt from Trolltech. The commercial support and development has stopped.

11. Based on Objective-C

- GNUstep.
- Cocoa.

Check Your Progress

1. Define the term Software Requirements Specification (SRS).
2. What is User Interface (UI) design?
3. Why mockup tool is used?
4. Explain about the windowing system software.

11.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. A Software Requirements Specification (SRS) is a description of a software system to be developed. It is modelled after business requirements

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specification (CONOPS), also known as a Stakeholder Requirements Specification (StRS). A CONcept of OPerations (abbreviated CONOPS, CONOPs, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. The software requirements specification lays out functional and non-functional requirements, and it may include a set of use cases that describe user interactions that the software must provide to the user for perfect interaction. Typically a SRS is written by a technical writer, a systems architect, or a software programmer. The Software Requirements Specification (SRS) is a communication tool between users and software designers.

2. User Interface (UI) design is the specific process that the software design engineers use for building interfaces in software or computerized devices, that typically focus on the appearance or style. The aim of the software designers is to create user-friendly interfaces so that the users can easily use the tools for completion of the task efficiently. User Interface (UI) design precisely refers to Graphical User Interfaces (GUIs) and other forms, for example voice-controlled interfaces.

   User Interface (UI) Design focuses on anticipating what users might need to do and ensuring that the interface has elements that are easy to access, understand, and use to facilitate those actions. UI brings together concepts from interaction design, visual design, and information architecture. The interface is designed after understanding the user's goals, skills, preferences, and requirements.

3. A mockup is a conceptual tool that is used especially in web development. It is basically an early draft of a website or web application. Mockups are primarily used for conception to convert ideas and concepts into a concrete design. They typically include the final navigation structure and detailed design elements so that they often resemble the final design of the website. A mockup is a static wireframe that includes more stylistic and visual UI details to present a realistic model of how the final page or application will look.

4. In computing, a windowing system or window system is software that manages separately different parts of display screens. It is a type of Graphical User Interface (GUI) which implements the WIMP (Windows, Icons, Menus, Pointer) paradigm for a User Interface (UI).

   Each currently running application is assigned a usually resizable and usually rectangular surface of the display to present its GUI to the user; these windows may overlap each other, as opposed to a tiling interface where they are not allowed to overlap. The programming of both the window decoration and of available widgets inside of the window, which are graphical elements for direct user interaction, such as sliders, buttons, etc., is eased and simplified through the use of widget toolkits.

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11.5 SUMMARY

- A Software Requirements Specification (SRS) is a description of a software system to be developed. It is modelled after business requirements specification (CONOPS), also known as a Stakeholder Requirements Specification (StRS).
- A CONcept of OPerations (abbreviated CONOPS, CONOPs, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system.
- CONOPS is used to communicate the quantitative and qualitative system characteristics to all stakeholders. CONOPS are widely used in the military, governmental services and other fields.
- The software requirements specification lays out functional and non-functional requirements, and it may include a set of use cases that describe user interactions that the software must provide to the user for perfect interaction.
- Typically a SRS is written by a technical writer, a systems architect, or a software programmer.
- The Software Requirements Specification (SRS) is a communication tool between users and software designers.
- A System Requirements Specification (SyRS), abbreviated as SysRS when need to be distinct from a Software Requirements Specification (SRS), is a structured collection of information that embodies the requirements of a system.
- A software tool is a programmatic software used to create, maintain, or else support other programs and applications.
- User Interface (UI) design is the specific process that the software design engineers use for building interfaces in software or computerized devices, that typically focus on the appearance or style.
- The aim of the software designers is to create user-friendly interfaces so that the users can easily use the tools for completion of the task efficiently.
- User Interface (UI) design precisely refers to Graphical User Interfaces (GUIs) and other forms, for example voice-controlled interfaces.
- User Interface (UI) Design focuses on anticipating what users might need to do and ensuring that the interface has elements that are easy to access, understand, and use to facilitate those actions. UI brings together concepts from interaction design, visual design, and information architecture.
- The interface is designed after understanding the user's goals, skills, preferences, and requirements.

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- The Graphical User Interfaces (GUIs) are essential when the users interact with visual representations on digital control panels, for example a computer's desktop is a GUI.
- The Voice-Controlled Interfaces (VUIs) are essential when the users interact with these through their voices. Most smart assistants, for example Siri on iPhone and Alexa on Amazon devices are termed as VUIs.
- In the field of Human Computer Interaction (HCI), a User Interface (UI) is the space where interactions between humans and machines occur. The goal of this interaction is to allow effective operation and control of the machine from the human end, whilst the machine simultaneously feeds back information that aids the user's decision-making process.
- A mockup is a conceptual tool that is used especially in web development. It is basically an early draft of a website or web application.
- Mockups are primarily used for conception to convert ideas and concepts into a concrete design. They typically include the final navigation structure and detailed design elements so that they often resemble the final design of the website.
- Mockups range from simple templates without functionality to interactive prototype-like designs created with dedicated mockup software.
- Smaller projects often do not require the use of mockups. In such a case, the templates are created directly in HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) or finished templates are adjusted to individual requirements.
- A mockup is a static wireframe that includes more stylistic and visual UI details to present a realistic model of how the final page or application will look.
- Multi-layered, complex mockups serve as the basis for prototypes which, depending on their complexity, are counted as middle to high dependability concepts.
- Presentation and image editing programs, such as Microsoft PowerPoint or Adobe Illustrator can be used to create simple user-friendly mockup tools.
- Dedicated mockup tools provide numerous template elements and the facility for creating modular mockup designs in addition to simple interaction sequences quickly and easily.
- Edraw can be used as an easy wireframe software for creating simple wireframes or working wireframe prototype.
- In computing, a windowing system or window system is software that manages separately different parts of display screens. It is a type of Graphical User Interface (GUI) which implements the WIMP (Windows, Icons, Menus, Pointer) paradigm for a User Interface (UI).

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- Each currently running application is assigned a usually resizable and usually rectangular surface of the display to present its GUI to the user; these windows may overlap each other, as opposed to a tiling interface where they are not allowed to overlap.
- Usually a window decoration is drawn around each window. The programming of both the window decoration and of available widgets inside of the window, which are graphical elements for direct user interaction, such as sliders, buttons, etc., is eased and simplified through the use of widget toolkits.
- The main component of any windowing system is usually called the display server, although alternative denominations, such as window server or compositor are also in use. Any application that runs and presents its GUI in a window, is a client of the display server.
- The display server is a key component in any Graphical User Interface (GUI), specifically the windowing system.

11.6 KEY WORDS

- **Software Requirements Specification (SRS):** A Software Requirements Specification (SRS) is a description of a software system to be developed. The Software Requirements Specification (SRS) is a communication tool between users and software designers.
- **System Requirements Specification (SyRS):** A System Requirements Specification (SyRS), abbreviated as SysRS when need to be distinct from a Software Requirements Specification (SRS), is a structured collection of information that embodies the requirements of a system.
- **Software tool:** A software tool is a programmatic software used to create, maintain, or else support other programs and applications.
- **User Interface (UI) design:** User Interface (UI) design is the specific process that the software design engineers use for building interfaces in software or computerized devices, that typically focus on the appearance or style.
- **Graphical User Interfaces (GUIs):** The Graphical User Interfaces (GUIs) are essential when the users interact with visual representations on digital control panels, for example a computer's desktop is a GUI.
- **Voice-Controlled Interfaces (VUIs):** The Voice-Controlled Interfaces (VUIs) are essential when the users interact with these through their voices. Most smart assistants, for example Siri on iPhone and Alexa on Amazon devices are termed as VUIs.

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11.7 SELF-ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. What are software tools specification methods?
2. Why interface building tools are used?
3. Define the significance of interface mockup tools.
4. Explain the types of software engineering tools.
5. Elaborate on windowing system layer.
6. What are GUI toolkit layers?

Long-Answer Questions

1. Briefly discuss the characteristic features and specifications of software tools specification methods giving appropriate examples.
2. Explain the structure of a Software Requirements Specification (SRS) giving an example for any organization.
3. Discuss the importance of interface building tools giving relevant examples.
4. Analyse the significance of interface mockup tools giving examples.
5. Describe the various types of software engineering tools with the help of examples.
6. Discuss in detail the characteristic features of windowing system layer.
7. Briefly discuss the significance of GUI toolkit layers giving examples.

11.8 FURTHER READINGS

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UNIT 12 INFORMATION SEARCH AND VISUALIZATION

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Structure

12.0 Introduction
12.1 Objectives
12.2 Information Search and Visualization - Database Query
12.2.1 Database Query
12.2.2 Advanced Filtering
12.2.3 Phrase Search in Documents
12.3 Multimedia Document Searches
12.4 Hypertext
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12.5.1 Static Web Content
12.5.2 Dynamic Web Content
12.6 Answers to Check Your Progress Questions
12.7 Summary
12.8 Key Words
12.9 Self Assessment Questions and Exercises
12.10 Further Readings

12.0 INTRODUCTION

The field of information visualization has emerged "From research in Human Computer Interaction (HCI), computer science, graphics, visual design, psychology, and business methods. It is gradually applied as a critical component in scientific research, digital libraries, data mining, financial data analysis, market studies, manufacturing production control, and drug discovery".

Information visualisation is the study of visual representations of abstract data to reinforce human cognition. The abstract data include both numerical and non-numerical data, such as text and geographic information. It is related to data visualization, infographics, and scientific visualization. One definition is that it is information visualization when the spatial representation, for example the page layout of a graphic design, is selected, whereas it is scientific visualization when the spatial representation is specified. Information theory is the scientific study of the quantification, storage and communication of information. Information is associated with data.

A search engine is an information retrieval system designed to help find information stored on a computer system. The search results are usually presented in a list and are commonly called hits. Search engines help to minimize the time required to find information and the amount of information which must be consulted, akin to other techniques for managing information overload. The most public, visible

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form of a search engine is a Web search engine which searches for information on the World Wide Web.

In computer science, phrase searching allows users to retrieve content from information systems, such as documents from file storage systems, records from databases, and web pages on the Internet, that contains a specific order and combination of words defined by the user.

Multimedia search enables information search using queries in multiple data types including text and other multimedia formats. Multimedia search can be implemented through multimodal search interfaces, i.e., interfaces that allow to submit search queries not only as textual requests, but also through other media.

Hypertext is text displayed on a computer display or other electronic devices with references (hyperlinks) to other text that the reader can immediately access. Hypertext documents are interconnected by hyperlinks, which are typically activated by a mouse click, keypress set, or screen touch. Apart from text, the term 'Hypertext' is also sometimes used to describe tables, images, and other presentational content formats with integrated hyperlinks. Hypertext is one of the key underlying concepts of the World Wide Web (WWW), where Web pages are often written in the HyperText Markup Language (HTML). As implemented on the Web, hypertext enables the easy-to-use publication of information over the Internet.

A server-side dynamic web page is a web page whose construction is controlled by an application server processing server-side scripts. In server-side scripting, parameters determine how the assembly of every new web page proceeds, including the setting up of more client-side processing. A static web page (sometimes called a flat page or a stationary page) is a web page that is delivered to the user's web browser exactly as stored, in contrast to dynamic web pages which are generated by a web application.

In this unit, you will study about the information search and visualization methods using database query, phrase search in documents, multimedia document searches, information visualization, advanced filtering, hypertext, web technology for static web content and dynamic web content.

12.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the significance of information search and visualization methods
- Explain the concept of information visualization
- Use database query for information search
- Know what advanced filtering is
- Accomplish phrase search in documents

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- Elaborate on multimedia document searches
- Describe the importance of hypertext
- Discuss about the web technology for static web content and dynamic web content

12.2 INFORMATION SEARCH AND VISUALIZATION - DATABASE QUERY

Information visualisation is the study of visual representations of abstract data to reinforce human cognition. The abstract data include both numerical and non-numerical data, such as text and geographic information. It is related to data visualization, infographics, and scientific visualization. One definition is that it is information visualization when the spatial representation, for example the page layout of a graphic design, is selected, whereas it is scientific visualization when the spatial representation is specified.

The field of information visualization has emerged "From research in Human Computer Interaction (HCI), computer science, graphics, visual design, psychology, and business methods. It is gradually applied as a critical component in scientific research, digital libraries, data mining, financial data analysis, market studies, manufacturing production control, and drug discovery".

Information visualization presumes that, "Visual representations and interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once. Information visualization focused on the creation of approaches for conveying abstract information in intuitive ways".

Information visualization is a set of technologies that uses visual computing to amplify human cognition with abstract information.

12.2.1 Database Query

In computing, a database is an organized collection of data stored and accessed electronically from a computer system. Where databases are more complex they are often developed using formal design and modeling techniques. Many DataBase Management Systems (DBMSs) use the Structured Query Language (SQL) as standard query format.

A database query is a similar action that is most closely associated with some sort of CRUD (Create, Read, Update, and Delete) function. A database query is a request to access data from a database to manipulate it or retrieve it.

Query Languages (QL), Data Query Languages or Database Query Languages (DQLs) are computer languages used to make queries in databases and information systems. A well-known example of the data query is the Structured Query Language (SQL). Fundamentally, the SQL is a domain-specific language

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used in programming and designed for managing data held in a Relational DataBase Management System (RDBMS), or for stream processing in a Relational Data Stream Management System (RDSMS). It is particularly useful in handling structured data, i.e., data incorporating relations among entities and variables. SQL can be categorised into four sub-languages, namely the Data Query Language (DQL), the Data Definition Language (DDL), the Data Control Language (DCL), and the Data Manipulation Language (DML). Typically, the DQL statements are used for performing queries on the data within schema objects. The purpose of DQL commands is to get the schema relation based on the query passed to it. Even though often considered part of DML, the SQL SELECT statement is considered as an example of DQL. When adding FROM or WHERE data manipulators to the SELECT statement the statement is then considered part of the DML.

A database query is, therefore, the principal mechanism for retrieving information from a database, i.e., a database query is key system for recovering data from a database. It comprises of predefined configuration of database questions.

The database query thus provides the considerable amount of help in the Human Computer Interface (HCI). The following points are the frameworks that elucidates and simplifies the user interfaces for textual search:

- Formulation – Expressing the Search
- Initiation of Action – Launching the Search
- Review of Results – Reading Messages and Outcomes
- Refinement – Formulating the Next Step
- Use – Compiling or Disseminating Insight

Example of Database Query

```
SELECT DOCUMENT#
FROM JOURNAL-DB
WHERE (DATE >= 2010 AND DATE <= 2021)
AND (LANGUAGE = ENGLISH OR FRENCH)
AND (PUBLISHER = VIKAS OR S CHAND OR ACM)
```

The above database query will perform the search in the database named as 'JOURNAL-DB' as per the query made in WHERE CLAUSE to display the selected results that match with the query.

In SQL, the database query makes use of the declarative SELECT statement. SELECT retrieves data from one or more tables or expressions. Standard SELECT statements have no persistent effects on the database. Some non-standard implementations of SELECT can have persistent effects, such as the SELECT INTO syntax provided in some databases. Queries allow the user

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to describe desired data, leaving the DataBase Management System (DBMS) to carry out planning, optimizing, and performing the physical operations necessary to produce that result as it selects.

A query includes a list of columns to include in the final result, normally immediately following the SELECT keyword. An asterisk "*" can be used to specify that the query should return all columns of the queried tables. SELECT is the most complex statement in SQL, with optional keywords and clauses that include the following:

- The FROM clause, which indicates the table(s) to retrieve data from. The FROM clause can include optional JOIN sub-clauses to specify the rules for joining tables.
- The WHERE clause includes a comparison predicate, which restricts the rows returned by the query. The WHERE clause eliminates all rows from the result set where the comparison predicate does not evaluate to True.
- The GROUP BY clause projects rows having common values into a smaller set of rows. GROUP BY is often used in conjunction with SQL aggregation functions or to eliminate duplicate rows from a result set. The WHERE clause is applied before the GROUP BY clause.
- The HAVING clause includes a predicate used to filter rows resulting from the GROUP BY clause. Because it acts on the results of the GROUP BY clause, aggregation functions can be used in the HAVING clause predicate.
- The ORDER BY clause identifies which column[s] to use to sort the resulting data, and in which direction to sort them (ascending or descending). Without an ORDER BY clause, the order of rows returned by an SQL query is undefined.
- The DISTINCT keyword eliminates duplicate data.
- The OFFSET clause specifies the number of rows to skip before starting to return data.
- The FETCH FIRST clause specifies the number of rows to return. Some SQL databases instead have non-standard alternatives, e.g., LIMIT, TOP or ROWNUM.

The clauses of a query have a particular order of execution, which is shown below denoted by the number on the right hand side of the each query clause.

SELECT <columns>	5.
FROM <table>	1.
WHERE <predicate on rows>	2.
GROUP BY <columns>	3.

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HAVING <predicate on groups>4.

ORDER BY <columns> 6.

OFFSET 7.

FETCH FIRST 8.

The following example of a SELECT query returns a list of expensive books. The query retrieves all rows from the 'Book' table in which the price column contains a value greater than 100.00. The result is sorted in ascending order by title. The asterisk (*) in the select list indicates that all columns of the Book table should be included in the result set.

```
SELECT *
 FROM Book
 WHERE price > 100.00
 ORDER BY title;
```

12.2.2 Advanced Filtering

One of the most powerful and dominant features of a database is the ability to filter data, i.e., to select only those records that match certain criteria. SQL strings enable the application of advanced filters. The SQL string matches to the portion of the full SQL SELECT Statement which follows the SQL WHERE Clause. For example, assume that the user wants to see when a particular site was visited. To display the result, select the specific records from the Visited table by using a WHERE clause in the query, as follows:

```
SELECT * FROM Visited WHERE site = 'DR-1';
```

The following result will be displayed:

id	site	dated
629	DR-1	1921-06-08
688	DR-1	1921-07-10
865	DR-1	1921-07-19

The database manager executes this query in two stages. First, it checks at each row in the Visited table to see which ones satisfy the WHERE. It then uses the column names following the SELECT keyword to determine which columns to display. This processing order specifies that the user can filter records using WHERE clause based on values in columns that are not then displayed:

```
SELECT id FROM Visited WHERE site = 'DR-1';
```

The following result will be displayed:

id
629
688
865

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Following are the advanced filtering procedures:

1. Filtering with Complex Boolean Queries

Boolean logic is used in filter and search restrictions to create more complex and precise criteria. Boolean logic uses AND, OR, NOT operators to narrow or broaden a search, or to exclude criteria from a search. By default, restrictions use the AND operator. The Boolean operators are used to build complex filters that find exactly what you are looking for in your console. Boolean queries involve the following special operator expressions:

xANDy - Both x and y must match in the result.

xORy - Either x or y must match in the result.

NOTx - x must not match in the result.

In these queries, x and y can be either simple terms or expressions, which together form a complex Boolean expression. Parentheses are used to clarify the syntax of complicated queries, such as

x and (y or z)

Some search engines often hide this syntax by providing several Boolean fields for input, such as:

ALL - All of the terms entered must appear in the result; a logical AND of all of the entered terms.

ANY - One of the terms entered must appear in the result; a logical OR of all of the entered terms.

NONE - None of the terms entered must appear in the result; a logical NOT of all of the entered terms.

This simple Boolean syntax typically has just two operators:

+term - Term is required in the result.

–term - Term must not be in the result, also known as term exclusion.

These simple operators can approximate more complex full Boolean syntax. For example,

x AND y could be entered as +x +y.

x AND NOT y could be entered as +x -y.

x AND (y OR z) could be entered as +x y z, assuming the search engine defaults to a Boolean OR of terms.

The behaviour may not be exactly the same, and depends greatly on the search engine, but this syntax is clearly a simple and effective alternative to full Boolean expressions.

2. Automatic Filtering

The 'Filtered Tables' pane includes filters when you add the selected filters to tables. Tables with row filters are shown as top-level nodes in the pane. For merge

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operations, tables to which filtering has been extended through a join filter are shown as child nodes.

Add: Click Add to launch a dialog box that enables you to filter table objects. Clicking Add for a snapshot or transactional publication launches a dialog box immediately. Clicking Add for a merge operation displays three choices, namely Add Filter; Add Join to Extend the Selected Filter; and Automatically Generate Filters.

Select Add Filter to launch the Add Filter dialog box. This dialog box allows you to apply row filters to a table. In the Add Filter dialog box, for example specify that a table with customer data should only contain data on Indian customers when it is replicated to Subscribers.

Select Add Join to Extend the Selected Filter to launch the Add Join dialog box. The Add Join dialog box allows you to extend a row filter so that it filters data in tables related to the table with the row filter. For example, if a customer table is filtered so that it only contains data on Indian customers and there is a related table for customer orders, then you can define a join between the two tables so that the orders table automatically only includes orders from Indian customers.

Select Automatically Generate Filters to launch the Generate Filters dialog box. This dialog box allows you to define a row filter on one table in a merge operation that replication automatically extends to other tables that are related through foreign key relationships. For example, a publication could include three tables: a customer table, an orders table (with a foreign key to the customer table), and an order details table (with a foreign key to the orders table). Define a row filter on the customer table, and replication will extend it to the other tables.

When filters are automatically generated by replication, any existing filters on the publication are deleted. To include both filters generated automatically and ones specified manually, generate filters first. You can only specify one set of automatically generated filters for each operation.

3. Dynamic Queries

Dynamic SQL is a programming technique that enables you to build SQL statements dynamically at runtime. You can create more general purpose, flexible applications by using dynamic SQL, for example, dynamic SQL lets you create a procedure that operates on a table whose name is not known until runtime. Dynamic SQL is typically used in cases where static SQL does not support the operation you want to perform, or in cases where you do not know the exact SQL statements that must be executed by a PL/SQL procedure. These SQL statements may depend on user input, or they may depend on processing work done by the program. PL/SQL (Procedural Language for SQL) is a combination of SQL along with the procedural features of programming languages.

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Characteristically, the Dynamic SQL is defined as a programming technique used for writing SQL queries during runtime. Dynamic SQL could be used to create general and flexible SQL queries.

Syntax for dynamic SQL is to make it string as follows:

'SELECT statement';

To run a dynamic SQL statement, run the stored procedure sp_executesql as shown below:

EXEC sp_executesql N'SELECT statement';

Use prefix N with the sp_executesql to use dynamic SQL as a Unicode string.

4. Faceted Metadata Search

Faceted search, or faceted navigation, provides an easy-to-use interface to narrow the results of a report and quickly locate specific data. You can create a faceted search page on an existing table and an arbitrary SQL query. Faceted search is a technique that involves augmenting traditional search techniques with a faceted navigation system, allowing users to narrow down search results by applying multiple filters based on faceted classification of the items. A faceted classification system classifies each information element along multiple explicit dimensions, called facets, enabling the classifications to be accessed and ordered in multiple ways rather than in a single, pre-determined, taxonomic order.

5. Query By Example (QBE)

Query By Example (QBE) is a database query language for relational databases. It was devised by Moshé M. Zloof at IBM Research during the mid-1970s, in parallel to the development of SQL. It is the first graphical query language, using visual tables where the user would enter commands, example elements and conditions. Many graphical front-ends for databases use the ideas from QBE today. Originally limited only for the purpose of retrieving data, QBE was later extended to allow other operations, such as inserts, deletes and updates, as well as creation of temporary tables.

Definition: Query By Example (commonly shortened to QBE) is a database query language for relational databases. It was developed at IBM in the 1970s. The development of SQL ran in parallel. QBE was developed for those users who only use databases occasionally, and who do not want to learn a complex language, such as SQL.

With QBE, users are presented with a visual schema of the database, which they edit with a special editor. When they are done, a parser translates their actions into a query in a regular query language, such as SQL. The user will be able to select tables and columns more quickly, for example by clicking on them, rather than typing their names.

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12.2.3 Phrase Search in Documents

In computer science, phrase searching allows users to retrieve content from information systems, such as documents from file storage systems, records from databases, and web pages on the Internet, that contains a specific order and combination of words defined by the user.

Phrase search is one of many search operators that are standard in search engine technology, along with Boolean operators AND, OR and NOT, truncation and wildcard operators commonly represented by the asterisk '*' symbol, field code operators which look for specific words in defined fields, such as the Author field in a periodical database, and proximity operators which look for defined words that appear close to one another, if not directly next to each other as in a phrase search. Search operators are used to refine a search when a simple keyword search provides too many unwanted results.

Although the exact functionality of each search engine is determined by its developers, phrase searching is normally accomplished by wrapping the desired phrase in quotation marks. For example, a search for "red apple" may return records that contain the word "apple", ones that contain "red", and ones that contain both words no matter where in the record they appear, i.e., assuming the search engine applies Boolean OR logic to its keyword search function, whereas a search for "red apple" will only return records that contain the phrase "red apple".

Phrase search is one of the more important techniques associated with optimizing the textual content of web pages in such a way that it is likely to be found by someone searching for a certain string of text.

12.3 MULTIMEDIA DOCUMENT SEARCHES

Multimedia is a form of communication that combines different content forms, such as text, audio, images, animations, or video into a single presentation. Popular examples of multimedia include video podcasts, audio slideshows and Animated videos. In the early years of multimedia, the term 'Rich Media' was synonymous with interactive multimedia. Over time, hypermedia extensions brought multimedia to the World Wide Web (WWW).

A MultiMedia DataBase (MMDB) is a collection of related for multimedia data. The multimedia data include one or more primary media data types, such as text, images, graphic objects (including drawings, sketches and illustrations) animation sequences, audio and video.

A MultiMedia DataBase Management System (MMDBMS) is a framework that manages different types of data potentially represented in a wide diversity of formats on a wide array of media sources. It provides support for multimedia data types, and facilitate for creation, storage, access, query and control of a multimedia database.

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A MultiMedia DataBase (MMDB) hosts one or more multimedia data types, i.e., text, images, graphic objects, audio, video, and animation sequences. These data types are broadly categorized into following three classes:

1. **Static Media** (Time-Independent: Image and Graphic Object).
2. **Dynamic Media** (Time-Dependent: Audio, Video and Animation).
3. **Dimensional Media** (3D Game and Computer Aided Drafting Programs).

Comparison of Multimedia Data Types

Following table shows comparison of different multimedia data types:

Medium	Elements	Time-Dependence
Graphic	Vectors, Regions	No
Image	Pixels	No
Audio	Sound, Volume	Yes
Video	Raster Images, Graphics	Yes

Additionally, a MultiMedia DataBase (MMDB) requires to manage additional information pertaining to the actual multimedia data. The information is about the following:

- **Media Data:** The actual data representing an object.
- **Media Format Data:** Information about the format of the media data after it goes through the acquisition, processing, and encoding phases.
- **Media Keyword Data:** The keyword descriptions, usually relating to the generation of the media data.
- **Media Feature Data:** Content dependent data, such as contain information about the distribution of colours, the kinds of textures and the different shapes present in an image.

The last three types are called **'Metadata'** as they describe several different aspects of the media data. The media keyword data and media feature data are used as indices for searching purpose. The media format data is used to present the retrieved information.

Requirements of Multimedia Databases

Similar to the traditional databases, multimedia databases should have the following requirements:

Integration: Data items do not need to be duplicated for different programs invocations.

Data Independence: Separate the database and the management from the application programs.

Concurrency Control: Allows concurrent transactions.

Persistence: Data objects can be saved and re-used by different transactions and program invocations.

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Privacy: Access and authorization control.

Integrity Control: Ensures database consistency between transactions.

Recovery: Failures of transactions should not affect the persistent data storage.

Query Support: Allows easy querying of multimedia data.

Multimedia databases should have the ability to uniformly query data (media data, textual data) represented in different formats and have the ability to simultaneously query different media sources and conduct classical database operations across them, i.e., Query Support.

Multimedia databases should have the ability to retrieve media objects from a local storage device in a good manner, i.e., Storage Support.

Multimedia databases should have the ability to take the response generated by a query and develop a presentation of that response in terms of audio-visual media and have the ability to deliver this presentation, i.e., Presentation and Delivery Support.

Multimedia Search

Multimedia search enables information search using queries in multiple data types including text and other multimedia formats. Multimedia search can be implemented through multimodal search interfaces, i.e., interfaces that allow to submit search queries not only as textual requests, but also through other media. Following are two distinguished methodologies in multimedia search:

1. **Metadata Search:** The search is made on the layers of metadata.
2. **Query By Example (QBE):** The interaction consists in submitting a piece of information, for example a video, an image or a piece of audio, for finding similar multimedia items.

Metadata Search

Search is made using the layers in metadata which contain information of the content of a multimedia file. Metadata search is easier, faster and effective because instead of working with complex material, such as an audio, a video or an image, it searches using text. Following three processes are used for metadata search method:

- Summarization of media content (feature extraction). The result of feature extraction is a description.
- Filtering of media descriptions, for example elimination of Redundancy.
- Categorization of media descriptions into classes.

Query By Example (QBE)

In Query By Example (QBE), the elements used to search is a multimedia content include image, audio, and video. In other words, the query is a media. Often, it is used audio-visual indexing. It will be essential to select the criteria that is to be

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used for creating metadata. The process of search can be divided in following three parts:

- Generate descriptors for the media which is to be used as query and the descriptors for the media in the existing database.
- Compare descriptors of the query and the existing database's media.
- List the media sorted by maximum coincidence.

Multimedia Search Engine

Following are the two big multimedia search engines according to function they perform.

Visual Search Engine

The 'Visual Search Engine' is used to perform image search and video search.

Image Search: Although usually it is used simple metadata search, increasingly is being used indexing methods for making the results of users queries more accurate using Query By Example (QBR), for example QR Codes.

Video Search: Videos can be searched for simple metadata or by complex metadata generated by indexing. The audio contained in the videos is usually scanned by audio search engines.

Audio Search Engine

Following are the different methods of audio searching:

Voice Search Engine: Allows the user to search using speech instead of text. It uses algorithms of speech recognition. An example of this technology is Google Voice Search.

Music Search Engine: Although most of applications which searches music works on simple metadata (artist, name of track, album…). There are some programs of music recognition, for example Shazam or SoundHound.

Categories of Multimedia Document Searches

Following are some important categories of multimedia document search.

Image Search: An image search is performed by specifying the destination where image search can be possible by entering the specifications of the preferred image or picture. Generally, basic drawing tools are utilised to construct layouts to pursue with. For complex searches, such as fingerprint matching, special software are developed where the user can search the machine for the predefined data of distinct features.

Map Search: Map search is another form of multimedia search used to perform online maps that are retrieved through mobile devices and search engines. Even though a structured database solution is mandatory for complex searches like searches with longitude/latitude. With the advanced database options, we can get the maps for all possible viewpoints, such as cities, states, countries, world maps, weather sheets, directions, etc.

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Design/Diagram Searches: Some design packages performs the search of designs or diagrams in the multimedia database, such as diagrams, blueprints, newspapers, etc.

Sound Search: Sound search can be easily performed using audio search in the database.

Video Search: Advanced projects, such as 'Infomedia' helps in retrieving video searches. They offer the brief of the videos or segmentations of frames from the video.

Animation Search: The frequency of animation search enhanced the popularity of Flash. It can be more possible to search various animations like moving boat.

12.4 HYPERTEXT

Hypertext is text displayed on a computer display or other electronic devices with references (hyperlinks) to other text that the reader can immediately access. Hypertext documents are interconnected by hyperlinks, which are typically activated by a mouse click, keypress set, or screen touch. Apart from text, the term 'Hypertext' is also sometimes used to describe tables, images, and other presentational content formats with integrated hyperlinks. Hypertext is one of the key underlying concepts of the World Wide Web (WWW), where Web pages are often written in the HyperText Markup Language (HTML). As implemented on the Web, hypertext enables the easy-to-use publication of information over the Internet.

Hypertext, therefore, can be defined as the text that has references to hyperlinks with quick access. Any content that gives a reference to another content can be comprehended as two hubs of data with the reference framing the connection. In hypertext, every one of the connections are dynamic and when clicked, opens something new.

Hypermedia is a data medium that holds diverse sorts of media, for example video, CD, et cetera, and also hyperlinks. Consequently, both hypertext and hypermedia alludes to an arrangement of connected data. A content may allude to joins, which may likewise have visuals or media. So hypertext can be utilized as a non-specific term to signify an archive, which may in certainty be disseminated over a few media.

In 1963, Ted Nelson coined the terms 'Hypertext' and 'Hypermedia' as part of a model he developed for creating and using linked content (first published reference 1965). He later worked with Andries van Dam to develop the Hypertext Editing System (text editing) in 1967 at Brown University. It was implemented using the terminal IBM 2250 with a light pen which was provided as a pointing device.

Types and Uses of Hypertext

Hypertext documents can either be static (prepared and stored in advance) or dynamic (continually changing in response to user input, such as dynamic web pages). Static hypertext can be used to cross-reference collections of data in documents, software applications, or books on CDs. A well-constructed system can also incorporate other user-interface conventions, such as menus and command lines. Links used in a hypertext document usually replace the current piece of hypertext with the destination document. A lesser known feature is 'StretchText', which expands or contracts the content in place, thereby giving more control to the reader in determining the level of detail of the displayed document. Some implementations support transclusion, where text or other content is included by reference and automatically rendered in place. Transclusion is the inclusion of part or all of an electronic document into one or more other documents by hypertext reference. Transclusion is usually performed when the referencing document is displayed, and is normally automatic and transparent to the end user. The result of transclusion is a single integrated document made of parts assembled dynamically from separate sources, possibly stored on different computers in disparate places.

Hypertext can be used to support very complex and dynamic systems of linking and cross-referencing. The most famous implementation of hypertext is the World Wide Web (WWW), written in the final months of 1990 and released on the Internet in 1991.

Forms of Hypertext

There are various forms of hypertext, each of which are structured differently. Following are four of the existing forms of hypertext:

1. **Axial Hypertexts:** Axial hypertexts are the most simple in structure. They are situated along an axis in a linear style. These hypertexts have a straight path from beginning to end and are fairly easy for the reader to follow. An example of an axial hypertext is "The Virtual Disappearance of Miriam".
2. **Arborescent Hypertexts:** Arborescent hypertexts are more complex than the axial form. They have a branching structure which resembles a tree. These hypertexts have one beginning but many possible endings. The ending that the reader finishes on depends on their decisions whilst reading the text. This is much like gamebook novels that allow readers to choose their own ending.
3. **Networked Hypertexts:** Networked hypertexts are more complex still than the two previous forms of hypertext. They consist of an interconnected system of nodes with no dominant axis of orientation. Unlike the arborescent form, networked hypertexts do not have any designated beginning or any designated endings. An example of a networked hypertext is "Shelley Jackson's Patchwork Girl".

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4. **Layered Hypertext:** Layered hypertext consist of two layers of linked pages. Each layer is doubly linked sequentially and a page in the top layer is doubly linked with a corresponding page in the bottom layer. The top layer contains plain text, the bottom multimedia layer provides photos, sounds and video.

12.5 WEB TECHNOLOGY

Web technology refers to the means by which computers communicate with each other using markup languages and multimedia packages. It gives us a way to interact with hosted information, like websites. Web technology involves the use of HyperText Markup Language (HTML) and Cascading Style Sheets (CSS). A website (also written as web site) is a collection of web pages and related content that is identified by a common domain name and published on at least one web server. Distinguished examples are wikipedia.org, google.com, and amazon.com.

All publicly accessible websites collectively constitute the World Wide Web (WWW). There are also private websites that can only be accessed on a private network, such as a company's internal website for its employees.

Websites are typically dedicated to a particular topic or purpose, such as news, education, commerce, entertainment, or social networking. Hyperlinking between web pages guides the navigation of the site, which often starts with a home page. Users can access websites on a range of devices, including desktops, laptops, tablets, and smartphones. The app used on these devices is called a web browser.

The World Wide Web (WWW) was created in 1990 by the British CERN physicist Tim Berners-Lee. On 30 April 1993, CERN announced that the World Wide Web would be free to use for anyone, contributing to the immense growth of the Web. Before the introduction of the HyperText Transfer Protocol (HTTP), other protocols, such as File Transfer Protocol (FTP) and the gopher protocol were used to retrieve individual files from a server. These protocols offer a simple directory structure which the user navigates and where they choose files to download. Documents were most often presented as plain text files without formatting or were encoded in word processor formats.

Fundamentally, the World Wide Web (WWW), commonly known as the Web, is an information system where documents and other web resources are identified by Uniform Resource Locators (URLs, such as https://example.com/), which may be interlinked by hyperlinks, and are accessible over the Internet. The resources of the Web are transferred via the HyperText Transfer Protocol (HTTP), may be accessed by users by a software application called a web browser, and are published by a software application called a web server. The World Wide Web or WWW is not synonymous with the Internet, which pre-dated the Web in some form by over two decades and upon which technologies the Web is built.

Web resources may be any type of downloaded media, but web pages are hypertext documents formatted in HyperText Markup Language (HTML). Special HTML syntax displays embedded hyperlinks with URLs which permits users to navigate to other web resources. In addition to text, web pages may contain references to images, video, audio, and software components which are either displayed or internally executed in the user's web browser to render pages or streams of multimedia content.

Multiple web resources with a common theme and usually a common domain name, make up a website. Websites are stored in computers that are running a web server, which is a program that responds to requests made over the Internet from web browsers running on a user's computer. Website content can be provided by a publisher, or interactively from user-generated content. Websites are provided for a myriad of informative, entertainment, commercial, and governmental reasons.

Websites can be used in various fashions, for example a personal website, a corporate website for a company, a government website, an organization website, etc. Websites can be the work of an individual, a business or other organization, and are typically dedicated to a particular topic or purpose. Any website can contain a hyperlink to any other website, so the distinction between individual sites, as perceived by the user, can be indistinct.

Some websites require user registration or subscription to access content. Examples of subscription websites include many business sites, news websites, academic journal websites, gaming websites, file-sharing websites, message boards, web-based email, social networking websites, websites providing real-time stock market data, as well as sites providing various other services.

Even though "web site" was the original spelling (sometimes capitalized "Web site", since "Web" is a proper noun when referring to the World Wide Web or WWW), this variant has become rarely used and therefore "website" has become the standard spelling. All major style guides, such as The Chicago Manual of Style and the AP Stylebook, have reflected this change.

A web application (or web app) is application software that runs on a web server, unlike computer-based software programs that are run locally on the Operating System (OS) of the device. Web applications are accessed by the user through a web browser with an active network connection. These applications are programmed using a client–server modelled structure—the user 'Client' is provided services through an off-site server that is hosted by a third-party. Examples of commonly-used web applications include web-mail, online retail sales, online banking, and online auctions.

Through Java, JavaScript, CSS, Flash, Silverlight and other technologies, application-specific methods, such as drawing on the screen, playing audio, and access to the keyboard and mouse are all possible. Many services have worked to combine all of these into a more familiar interface that adopts the appearance of an operating system. General-purpose techniques, such as drag and drop are also

supported by these technologies. Web developers often use client-side scripting to add functionality, especially to create an interactive experience that does not require page reloading. Recently, technologies have been developed to coordinate client-side scripting with server-side technologies, such as ASP.NET, J2EE, Perl/Plack and PHP.

Ajax, a web development technique using a combination of various technologies, is an example of technology that creates a more interactive experience.

Web Development

Web development is the work involved in developing a Web site for the Internet (World Wide Web or WWW) or an intranet (a private network). Web development can range from developing a simple single static page of plain text to complex web applications, electronic businesses, and social network services. A more comprehensive list of tasks to which Web development commonly refers, may include Web engineering, Web design, Web content development, client liaison, client-side/server-side scripting, Web server and network security configuration, and e-commerce development.

Among Web professionals, the term "Web development" usually refers to the main non-design aspects of building Web sites, writing markup and coding. Web development may use Content Management Systems (CMS) to make content changes easier and available with basic technical skills.

For larger organizations and businesses, Web development teams can consist of hundreds of people (Web developers) and follow standard methods like Agile methodologies while developing Web sites. Smaller organizations may only require a single permanent or contracting developer, or secondary assignment to related job positions, such as a graphic designer or information systems technician. Web development may be a collaborative effort between departments rather than the domain of a designated department. There are three kinds of Web developer specialization, namely front-end developer, back-end developer, and full-stack developer. Front-end developers are responsible for behaviour and visuals that run in the user browser, while back-end developers deal with the servers.

12.5.1 Static Web Content

A **static website** is one that has web pages stored on the server in the format that is sent to a client web browser. It is primarily coded in HyperText Markup Language (HTML); Cascading Style Sheets (CSS) are used to control appearance beyond basic HTML. Images are commonly used to create the desired appearance and as part of the main content. Audio or video might also be considered "Static" content if it plays automatically or is generally non-interactive. This type of website usually displays the same information to all visitors. Similar to handing out a printed brochure to customers or clients, a static website will generally provide consistent, standard information for an extended period of time. Although the website owner

may make updates periodically, it is a manual process to edit the text, photos, and other content and may require basic website design skills and software. Simple forms or marketing examples of websites, such as classic website, a five-page website or a brochure website are often static websites, because they present pre-defined, static information to the user. This may include information about a company and its products and services through text, photos, animations, audio/video, and navigation menus.

Static websites may still use Server Side Includes (SSI) as an editing convenience, such as sharing a common menu bar across many pages.

The **static web page** (sometimes called a flat page or a stationary page) is a web page that is delivered to the user's web browser exactly as stored, in contrast to dynamic web pages which are generated by a web application.

Consequently, a static web page displays the same information for all users, from all contexts, subject to modern capabilities of a web server to negotiate content-type or language of the document where such versions are available and the server is configured to do so.

Static web pages are often HTML documents stored as files in the file system and made available by the web server over HTTP (nevertheless URLs ending with "**.html**" are not always static). However, loose interpretations of the term could include web pages stored in a database, and could even include pages formatted using a template and served through an application server, as long as the page served is unchanging and presented essentially as stored.

Static web pages are suitable for content that never or rarely needs to be updated, though modern web template systems are changing this. Maintaining large numbers of static pages as files can be impractical without automated tools, such as static site generators.

Advantages of a Static Website

Following are the advantages of a static website:

- Provide improved security over dynamic websites, dynamic websites are at risk to web shell attacks if a vulnerability is present.
- Improved performance for end users compared to dynamic websites.
- Fewer or no dependencies on systems, such as databases or other application servers.
- Cost savings from utilizing cloud storage, as opposed to a hosted environment.
- Security configurations are easy to setup, which makes it more secure.

Disadvantages of a Static Website

- Dynamic functionality must be performed on the client side.

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12.5.2 Dynamic Web Content

A **dynamic website** is one that changes or customizes itself frequently and automatically. Server-side dynamic pages are generated "On The Fly" by computer code that produces the HTML, CSS are responsible for appearance and thus are static files. There are a wide range of software systems, such as CGI (Common Gateway Interface), Java Servlets and Java Server Pages (JSP), Active Server Pages and ColdFusion (CFML) that are available to generate dynamic web systems and dynamic sites. Various web application frameworks and web template systems are available for general-use programming languages, such as Perl, PHP, Python and Ruby to make it faster and easier to create complex dynamic websites.

A site can display the current state of a dialogue between users, monitor a changing situation, or provide information in some way personalized to the requirements of the individual user. For example, when the front page of a news site is requested, the code running on the webserver might combine stored HTML fragments with news stories retrieved from a database or another website via RSS to produce a page that includes the latest information. Dynamic sites can be interactive by using HTML forms, storing and reading back browser cookies, or by creating a series of pages that reflect the previous history of clicks. Another example of dynamic content is when a retail website with a database of media products allows a user to input a search request, for example for the keyword Beatles. In response, the content of the web page will spontaneously change the way it looked before, and will then display a list of Beatles products like CDs, DVDs, and books. Dynamic HTML uses JavaScript code to instruct the web browser how to interactively modify the page contents. One way to simulate a certain type of dynamic website while avoiding the performance loss of initiating the dynamic engine on a per-user or per-connection basis is to periodically automatically regenerate a large series of static pages.

A server-side dynamic web page is a web page whose construction is controlled by an application server processing server-side scripts. In server-side scripting, parameters determine how the assembly of every new web page proceeds, including the setting up of more client-side processing.

A **client-side dynamic web page** processes the web page using JavaScript running in the browser as it loads. JavaScript can interact with the page via Document Object Model (DOM) to query page state and modify it. Even though a web page can be dynamic on the client-side, it can still be hosted on a static hosting service, such as GitHub Pages or Amazon S3 as long as any server-side code is not included. A dynamic web page is then reloaded by the user or by a computer program to change some variable content. The updating information could come from the server, or from changes made to that page's DOM.

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Client-side scripting is changing interface behaviours within a **specific web page** in response to mouse or keyboard actions, or at specified timing events. In this case, the dynamic behaviour occurs within the presentation. The client-side content is generated on the user's local computer system.

Such web pages use presentation technology called rich interfaced pages. Client-side scripting languages like JavaScript or ActionScript, used for Dynamic HTML (DHTML) and Flash technologies, respectively, are frequently used to orchestrate media types (sound, animations, changing text, etc.) of the presentation. Client-side scripting also allows the use of remote scripting, a technique by which the DHTML page requests additional information from a server, using a hidden frame, XMLHttpRequests, or a Web service.

Client-side scripting, server-side scripting, or a combination of these make for the dynamic web experience in a browser.

The client-side content is generated on the client's computer. The web browser retrieves a page from the server, then processes the code embedded in the page (typically written in JavaScript) and displays the retrieved page's content to the user.

All of the **client** and **server components** that collectively build a **dynamic web page** are called a **web application**. Web applications manage user interactions, state, security, and performance.

Check Your Progress

1. Explain the term information visualisation.
2. Define the terms database and database query.
3. Why Boolean logic is used in filters?
4. Explain about the MultiMedia DataBase (MMDB) and its categories.
5. What is hypertext?
6. Describe the importance of web technology.
7. Elaborate on the terms static website and dynamic website.

12.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Information visualisation is the study of visual representations of abstract data to reinforce human cognition. The abstract data include both numerical and non-numerical data, such as text and geographic information. It is related to data visualization, infographics, and scientific visualization. One definition

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is that it is information visualization when the spatial representation, for example the page layout of a graphic design, is selected, whereas it is scientific visualization when the spatial representation is specified.

Information visualization presumes that, "Visual representations and interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once. Information visualization focused on the creation of approaches for conveying abstract information in intuitive ways".

Information visualization is a set of technologies that uses visual computing to amplify human cognition with abstract information.

2. In computing, a database is an organized collection of data stored and accessed electronically from a computer system. Where databases are more complex they are often developed using formal design and modeling techniques. Many DataBase Management Systems (DBMSs) use the Structured Query Language (SQL) as standard query format.

   A database query is a similar action that is most closely associated with some sort of CRUD (Create, Read, Update, and Delete) function. A database query is a request to access data from a database to manipulate it or retrieve it.

3. Boolean logic is used in filter and search restrictions to create more complex and precise criteria. Boolean logic uses AND, OR, NOT operators to narrow or broaden a search, or to exclude criteria from a search. By default, restrictions use the AND operator. The Boolean operators are used to build complex filters that find exactly what you are looking for in your console.

4. A MultiMedia DataBase (MMDB) is a collection of related for multimedia data. The multimedia data include one or more primary media data types, such as text, images, graphic objects (including drawings, sketches and illustrations) animation sequences, audio and video. A MultiMedia DataBase (MMDB) hosts one or more multimedia data types, i.e., text, images, graphic objects, audio, video, and animation sequences. These data types are broadly categorized into following three classes:

   - Static Media (Time-Independent: Image and Graphic Object).
   - Dynamic Media (Time-Dependent: Audio, Video and Animation).
   - Dimensional Media (3D Game and Computer Aided Drafting Programs).

5. Hypertext is text displayed on a computer display or other electronic devices with references (hyperlinks) to other text that the reader can immediately access. Hypertext documents are interconnected by hyperlinks, which are typically activated by a mouse click, keypress set, or screen touch. Apart from text, the term 'Hypertext' is also sometimes used to describe tables, images, and other presentational content formats with integrated hyperlinks.

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Hypertext is one of the key underlying concepts of the World Wide Web (WWW), where Web pages are often written in the HyperText Markup Language (HTML). As implemented on the Web, hypertext enables the easy-to-use publication of information over the Internet.

6. Web technology refers to the means by which computers communicate with each other using markup languages and multimedia packages. It gives us a way to interact with hosted information, like websites. Web technology involves the use of HyperText Markup Language (HTML) and Cascading Style Sheets (CSS). A website (also written as web site) is a collection of web pages and related content that is identified by a common domain name and published on at least one web server.
7. A static website is one that has web pages stored on the server in the format that is sent to a client web browser. It is primarily coded in HyperText Markup Language (HTML); Cascading Style Sheets (CSS) are used to control appearance beyond basic HTML. Images are commonly used to create the desired appearance and as part of the main content. Audio or video might also be considered "Static" content if it plays automatically or is generally non-interactive. This type of website usually displays the same information to all visitors.

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12.7 SUMMARY

- Information visualisation is the study of visual representations of abstract data to reinforce human cognition. The abstract data include both numerical and non-numerical data, such as text and geographic information.
- Information visualisation is related to data visualization, infographics, and scientific visualization.
- The field of information visualization has emerged "From research in Human Computer Interaction (HCI), computer science, graphics, visual design, psychology, and business methods. It is gradually applied as a critical component in scientific research, digital libraries, data mining, financial data analysis, market studies, manufacturing production control, and drug discovery".

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- Information visualization presumes that, "Visual representations and interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once. Information visualization focused on the creation of approaches for conveying abstract information in intuitive ways".
- Information visualization is a set of technologies that uses visual computing to amplify human cognition with abstract information.
- In computing, a database is an organized collection of data stored and accessed electronically from a computer system. Where databases are more complex they are often developed using formal design and modeling techniques.
- Many DataBase Management Systems (DBMSs) use the Structured Query Language (SQL) as standard query format.
- A database query is a similar action that is most closely associated with some sort of CRUD (Create, Read, Update, and Delete) function. A database query is a request to access data from a database to manipulate it or retrieve it.
- Query Languages (QL), Data Query Languages or Database Query Languages (DQLs) are computer languages used to make queries in databases and information systems.
- A well-known example of the data query is the Structured Query Language (SQL).
- Fundamentally, the SQL is a domain-specific language used in programming and designed for managing data held in a Relational DataBase Management System (RDBMS), or for stream processing in a Relational Data Stream Management System (RDSMS).
- SQL can be categorised into four sub-languages, namely the Data Query Language (DQL), the Data Definition Language (DDL), the Data Control Language (DCL), and the Data Manipulation Language (DML).
- Typically, the DQL statements are used for performing queries on the data within schema objects. The purpose of DQL commands is to get the schema relation based on the query passed to it.
- A database query is, therefore, the principal mechanism for retrieving information from a database, i.e., a database query is key system for recovering data from a database. It comprises of predefined configuration of database questions.
- A query includes a list of columns to include in the final result, normally immediately following the SELECT keyword. An asterisk "*" can be used to specify that the query should return all columns of the queried tables.

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- One of the most powerful and dominant features of a database is the ability to filter data, i.e., to select only those records that match certain criteria.
- SQL strings enable the application of advanced filters. The SQL string matches to the portion of the full SQL SELECT Statement which follows the SQL WHERE Clause.
- Boolean logic is used in filter and search restrictions to create more complex and precise criteria.
- Boolean logic uses AND, OR, NOT operators to narrow or broaden a search or to exclude criteria from a search. By default, restrictions use the AND operator.
- Dynamic SQL is a programming technique that enables you to build SQL statements dynamically at runtime. You can create more general purpose, flexible applications by using dynamic SQL, for example, dynamic SQL lets you create a procedure that operates on a table whose name is not known until runtime.
- These SQL statements may depend on user input, or they may depend on processing work done by the program.
- PL/SQL (Procedural Language for SQL) is a combination of SQL along with the procedural features of programming languages.
- Characteristically, the Dynamic SQL is defined as a programming technique used for writing SQL queries during runtime. Dynamic SQL could be used to create general and flexible SQL queries.
- Faceted search is a technique that involves augmenting traditional search techniques with a faceted navigation system, allowing users to narrow down search results by applying multiple filters based on faceted classification of the items.
- A faceted classification system classifies each information element along multiple explicit dimensions, called facets, enabling the classifications to be accessed and ordered in multiple ways rather than in a single, pre-determined, taxonomic order.
- Query By Example (QBE) is a database query language for relational databases. It was devised by Moshé M. Zloof at IBM Research during the mid-1970s, in parallel to the development of SQL. It is the first graphical query language, using visual tables where the user would enter commands, example elements and conditions.
- Originally limited only for the purpose of retrieving data, QBE was later extended to allow other operations, such as inserts, deletes and updates, as well as creation of temporary tables.

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- QBE was developed for those users who only use databases occasionally, and who do not want to learn a complex language, such as SQL.
- Phrase searching allows users to retrieve content from information systems, such as documents from file storage systems, records from databases, and web pages on the Internet, that contains a specific order and combination of words defined by the user.
- Phrase search is one of many search operators that are standard in search engine technology, along with Boolean operators AND, OR and NOT, truncation and wildcard operators commonly represented by the asterisk '*' symbol, field code operators which look for specific words in defined fields.
- Search operators are used to refine a search when a simple keyword search provides too many unwanted results.
- A MultiMedia DataBase (MMDB) is a collection of related for multimedia data. The multimedia data include one or more primary media data types, such as text, images, graphic objects (including drawings, sketches and illustrations) animation sequences, audio and video.
- A MultiMedia DataBase Management System (MMDBMS) is a framework that manages different types of data potentially represented in a wide diversity of formats on a wide array of media sources. It provides support for multimedia data types, and facilitate for creation, storage, access, query and control of a multimedia database.
- A MultiMedia DataBase (MMDB) hosts one or more multimedia data types, i.e., text, images, graphic objects, audio, video, and animation sequences.
- Multimedia search enables information search using queries in multiple data types including text and other multimedia formats.
- Multimedia search can be implemented through multimodal search interfaces, i.e., interfaces that allow to submit search queries not only as textual requests, but also through other media.
- An image search is performed by specifying the destination where image search can be possible by entering the specifications of the preferred image or picture. Generally, basic drawing tools are utilised to construct layouts to pursue with.
- For complex searches, such as fingerprint matching, special software are developed where the user can search the machine for the predefined data of distinct features.
- Map search is another form of multimedia search used to perform online maps are retrieved through mobile devices and search engines. With the

advanced database options, we can get the maps for all possible viewpoints, such as cities, states, countries, world maps, weather sheets, directions, etc.

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- Hypertext is text displayed on a computer display or other electronic devices with references (hyperlinks) to other text that the reader can immediately access.
- Hypertext documents are interconnected by hyperlinks, which are typically activated by a mouse click, keypress set, or screen touch.
- Apart from text, the term 'Hypertext' is also sometimes used to describe tables, images, and other presentational content formats with integrated hyperlinks.
- Hypertext is one of the key underlying concepts of the World Wide Web (WWW), where Web pages are often written in the HyperText Markup Language (HTML). As implemented on the Web, hypertext enables the easy-to-use publication of information over the Internet.
- Hypertext documents can either be static (prepared and stored in advance) or dynamic (continually changing in response to user input, such as dynamic web pages).
- Static hypertext can be used to cross-reference collections of data in documents, software applications, or books on CDs. A well-constructed system can also incorporate other user-interface conventions, such as menus and command lines.
- Web technology refers to the means by which computers communicate with each other using markup languages and multimedia packages. It gives us a way to interact with hosted information, like websites. Web technology involves the use of HyperText Markup Language (HTML) and Cascading Style Sheets (CSS).
- A website (also written as web site) is a collection of web pages and related content that is identified by a common domain name and published on at least one web server. Distinguished examples are wikipedia.org, google.com, and amazon.com.
- All publicly accessible websites collectively constitute the World Wide Web (WWW). There are also private websites that can only be accessed on a private network, such as a company's internal website for its employees.
- Websites are typically dedicated to a particular topic or purpose, such as news, education, commerce, entertainment, or social networking.
- Hyperlinking between web pages guides the navigation of the site, which often starts with a home page.

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- Users can access websites on a range of devices, including desktops, laptops, tablets, and smartphones. The app used on these devices is called a web browser.
- Through Java, JavaScript, CSS, Flash, Silverlight and other technologies, application-specific methods, such as drawing on the screen, playing audio, and access to the keyboard and mouse are all possible.
- Web development is the work involved in developing a Web site for the Internet (World Wide Web or WWW) or an intranet (a private network). Web development can range from developing a simple single static page of plain text to complex web applications, electronic businesses, and social network services.
- A static website is one that has web pages stored on the server in the format that is sent to a client web browser. It is primarily coded in HyperText Markup Language (HTML); Cascading Style Sheets (CSS) are used to control appearance beyond basic HTML.
- Images are commonly used to create the desired appearance and as part of the main content. Audio or video might also be considered "Static" content if it plays automatically or is generally non-interactive. This type of website usually displays the same information to all visitors.
- The static web page (sometimes called a flat page or a stationary page) is a web page that is delivered to the user's web browser exactly as stored, in contrast to dynamic web pages which are generated by a web application.
- A dynamic website is one that changes or customizes itself frequently and automatically. Server-side dynamic pages are generated "On The Fly" by computer code that produces the HTML, CSS are responsible for appearance and thus are static files.
- There are a wide range of software systems, such as CGI (Common Gateway Interface), Java Servlets and Java Server Pages (JSP), Active Server Pages and ColdFusion (CFML) that are available to generate dynamic web systems and dynamic sites.
- A server-side dynamic web page is a web page whose construction is controlled by an application server processing server-side scripts.
- In server-side scripting, parameters determine how the assembly of every new web page proceeds, including the setting up of more client-side processing.
- A client-side dynamic web page processes the web page using JavaScript running in the browser as it loads. JavaScript can interact with the page via Document Object Model (DOM) to query page state and modify it.

- All of the client and server components that collectively build a dynamic web page are called a web application. Web applications manage user interactions, state, security, and performance.

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12.8 KEY WORDS

- **Information visualization:** Information visualization is a set of technologies that uses visual computing to amplify human cognition with abstract information.
- **Database:** In computing, a database is an organized collection of data stored and accessed electronically from a computer system.
- **Database query:** A database query is a similar action that is most closely associated with some sort of CRUD (Create, Read, Update, and Delete) function, i.e., a database query is a request to access data from a database to manipulate it or retrieve it.
- **Faceted search:** Faceted search, or faceted navigation, provides an easy-to-use interface to narrow the results of a report and quickly locate specific data, it is a technique that involves augmenting traditional search techniques with a faceted navigation system, allowing users to narrow down search results by applying multiple filters based on faceted classification of the items.
- **Query By Example (QBE):** Query By Example (QBE) is a database query language for relational databases, devised by Moshé M. Zloof at IBM Research in parallel to the development of SQL. It is the first graphical query language, using visual tables where the user would enter commands, example elements and conditions.
- **MultiMedia DataBase (MMDB):** A MultiMedia DataBase (MMDB) is a collection of related multimedia data, the multimedia data include one or more primary media data types, such as text, images, graphic objects (including drawings, sketches and illustrations) animation sequences, audio and video.
- **Multimedia search:** Multimedia search enables information search using queries in multiple data types including text and other multimedia formats, i.e., interfaces that allow to submit search queries not only as textual requests, but also through other media.
- **Image search:** An image search is performed by specifying the destination where image search can be possible by entering the specifications of the preferred image or picture.
- **Map search:** Map search is a form of multimedia search used to perform online maps that are retrieved through mobile devices and search engines, i.e., the maps for all possible viewpoints, such as cities, states, countries, world maps, weather sheets, directions, etc.

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- **Hypertext:** Hypertext is text displayed on a computer display or other electronic devices with references (hyperlinks) to other text that the reader can immediately access. Hypertext documents are interconnected by hyperlinks, which are typically activated by a mouse click, keypress set, or screen touch. **Web technology:** Web technology refers to the means by which computers communicate with each other using markup languages (HyperText Markup Language (HTML) and Cascading Style Sheets (CSS)) and multimedia packages to interact with hosted information, such as the websites.
- **Web application:** All of the client and server components that collectively build a dynamic web page are called a web application. Web applications manage user interactions, state, security, and performance.

12.9 SELF-ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define the term information search.
2. What is information visualization?
3. Explain the term database query.
4. What is CRUD?
5. Why an asterisk "*" is used in the query?
6. What is advanced filtering?
7. Why phrase search is done in documents?
8. Elaborate on multimedia document searches.
9. Explain the importance of hypertext.
10. Describe the term web technology.
11. What is static web content?
12. Explain about the dynamic web content.

Long-Answer Questions

1. Briefly discuss the basics of information search and information visualization with reference to Human Computer Interaction (HCI) giving appropriate examples.

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2. Explain the concept and specification of database query with the help of relevant examples.
3. "In SQL, the database query makes use of the declarative SELECT statement." Justify the statement giving significant examples.
4. Explain the complex statements in SQL that use SELECT with optional keywords and clauses. Also define the particular order of execution of clauses of a query giving appropriate examples.
5. Discuss in detail the advanced filtering options used in query and search procedures giving their characteristic features and relevant examples.
6. Elaborate on the phrase search in documents with the help of examples.
7. Explain how multimedia document are searched? Give examples.
8. How the MultiMedia DataBase (MMDB) and MultiMedia DataBase Management System (MMDBMS) frameworks manages different types of data potentially on a wide array of media sources? Explain giving examples.
9. Explain the essential requirements of multimedia databases and multimedia search procedures.
10. Discuss in detail about the types, forms and uses of hypertext and HyperText Markup Language (HTML) giving examples.
11. Briefly discuss the specifications and characteristic features of web technology on the basis of markup languages and multimedia packages.
12. Elaborate on the Web development process.
13. Explain the features and significance of static web content and static website.
14. Discuss briefly the specifications of dynamic web content, dynamic website, server-side dynamic web page and client-side dynamic web page processes.

12.10 FURTHER READINGS

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UNIT 13 INFORMATION SEARCH - USABILITY AND PROTOTYPES

Structure

13.0 Introduction
13.1 Objectives
13.2 Information Search - Usability and Prototypes
13.2.1 Prototypes
13.3 System Response Time
13.4 Dealing with Time Delays
13.4.1 Blinking for Attention
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13.6 Summary
13.7 Key Words
13.8 Self Assessment Questions and Exercises
13.9 Further Readings

13.0 INTRODUCTION

Consumers engage in both internal and external information search. Internal search involves the consumer identifying alternatives from his or her memory. Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In software engineering, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use. A prototype is mainly used for testing, discovery, and communication. Its aim is to gather user feedback on design and provide it to designers. The primary function is that of a communicator, not precision or thoroughness. A prototype helps you imagine a concept and gives you an idea of how the app will look and function. It also helps in the definition of tasks, their flow, the system itself, and the screens that make up the interface.

Response time is the total amount of time it takes to respond to a request for service. That service can be anything from a memory fetch to a disk IO, to a complex database query, or loading a full web page. Ignoring transmission time for a moment, the response time is the sum of the service time and wait time. Human computer interaction includes two-time phases, System Response Time (SRT), the interval of time between user input and computer response, and User Response Time (URT), the time that elapses between computer response and user input.

The time delay between a user's initiation of a command on a computer and the system's completion and display of the result is known as the System Response Time (SRT). These times can range from milliseconds to minutes depending on numerous variables, including the complexity of the task and the processing power of the system. SRT is also a major source of frustration for computer users, and it can severely degrade the systems and different applications usability. Therefore, this temporal aspect of Human Computer Interaction (HCI) is an important component of a system's overall design.

In this unit, you will study about the significance of information search, usability and prototypes, components of usability, system response time and user response time, various time delays and blinking of attention.

13.1 OBJECTIVES

After going through this unit, you will be able to:

- Analyse the significance of information search
- Interpret the significance of usability and prototypes
- Learn about the components of usability
- Know about the significance of prototype
- Discuss about the system response time and user response time
- Learn about the various time delays
- Know about blinking of attention

13.2 INFORMATION SEARCH – USABILITY AND PROTOTYPES

The field of Human Computer Interaction (HCI) discusses how people communicate with computers. Knowledge discovery can be enjoyable, but several commentators have expressed concerns about information overload and anxiety. However, there is reason to believe that the next generation of digital libraries and databases would make it easier for a broader range of users to explore expanding information spaces. When the number and variety of information collections expands, it becomes more difficult to explore them. When the source of knowledge is the size of a book, a library, or even larger, it may be difficult to find known objects or search for an overview. Information-search experts are well-versed in emphasis and narrowing techniques, but none of them are being applied for widespread use.

There are two main components.

- Usability
- Prototypes

Usability

Usability is a consistency metric that measures how convenient it is to use a user interface. During the design process, the term usability also applies to strategies for enhancing ease-of-use. Usability is a term used in user interface design to describe how well and easily a user can interact with a given interface. Usability encompasses several other terms, including learnability and usefulness. In user-centered design, one of the most critical criteria of a user interface is its usability.

Areas of Use of the Usability Concept

Usability is not all about Web interfaces. Usability is a term used to describe any programme or electronic system that requires human-machine interaction. Computer science and electronics are the most popular applications. Usability, on the other hand, is not limited to human-computer interaction. The usability of a design is determined by how well its features accommodate users' needs and contexts.

There are five **quality components to define** usability:

- Ease of Learning
- Efficiency
- Effectiveness and Memorability
- Error Tolerance
- Satisfaction and Engagement

Ease of Learning

New users can accomplish goals easily and even more easily on future visits. It talks about When users first experience the design, how simple is it for them to complete basic tasks?

Efficiency

Users can perform tasks quickly through the easiest process. It answers the question how easily users can perform tasks once they have mastered the design.

Effectiveness and Memorability

It supports users in completing actions accurately. How quickly will users re-establish proficiency when they return to the design after a time of inactivity?

Error Tolerance

It supports a variety of user behaviours and only displays an error when something is wrong. This is accomplished by determining the number, type, and severity of common user errors, as well as the ease with which users can recover from those errors.

Satisfaction and Engagement

It is easy to use and suitable for the industry/topic, according to users. How enjoyable is it to work with the design?

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Table 13.1 shows five **quality components.**

Table 13.1 *Five Quality Components*

Usability objective	Effectiveness measures	Efficiency measures	Satisfaction measures
Suitability for the task	Percentage of goals achieved	Time to complete a task	Rating scale for satisfaction
Appropriate for trained users	Number of power features used	Efficiency relative to expert user	Rating scale for ease of learning
Learnability	Percentage of functions learned	Time to learn criterion	Rating scale for ease of learning
Error tolerance	Percentage of errors corrected successfully	Time spent on correcting errors	Rating scale for error handling

13.2.1 Prototypes

A prototype is mainly used for testing, discovery, and communication. Its aim is to gather user feedback on design and provide it to designers. The primary function is that of a communicator, not precision or thoroughness. A prototype helps you imagine a concept and gives you an idea of how the app will look and function. It also helps in the definition of tasks, their flow, the system itself, and the screens that make up the interface.

A prototype can have a lot of scope, with as many features as possible to show ideas and overall organisation, or it can have a lot of depth, with more information on a specific function or mission to concentrate on specific design aspects. A prototype, by definition, cannot be used to test all a system's features, only those that are significant in some way. A prototype, which is especially useful early in the design process, should be able to be quickly modified as testing is carried out. The fidelity of a prototype is defined by the accuracy and thoroughness with which it replicates a system's screens and user interaction. From rough hand-drawn drawings to fully functional applications, prototypes vary in fidelity from low to high. The practise of developing software prototypes, or unfinished versions of the software programme being created, is known as software prototyping. It is a software development activity that is like prototyping, which is used in other fields including mechanical engineering and manufacturing. A prototype usually only simulates a few elements of and can be entirely different from the real thing.

Prototyping Benefits

Users will provide useful input to the software designer and implementer early in the project. The client and the contractor will assess whether the software produced corresponds to the software specification on which the software programme is based. It also gives the software engineer an idea of the accuracy of the initial project forecasts and whether the planned deadlines and targets can be met. Since

its proposal in the early 1970s, the degree of completeness and the methods used in prototyping have been in progress and debate. One would assume that as technology becomes more advanced and processing speeds become faster these delays would lessen. This would be true only if the complexity of the tasks and richness of the content did not increase, too. However, the opposite is true; programs and Websites have become increasingly complex offering more and more features, thereby increasing the amount of information that needs to be processed. The more data that are processed, the longer the delays in the system are to be expected.

Check Your Progress

1. What are the two components of information search?
2. Define the term prototype.
3. What is known as software prototyping?
4. List any one benefit of prototyping.

13.3 SYSTEM RESPONSE TIME

One of the early catalysts for SRT research was time-shared computer systems. Computer networks used to be massive and costly, making it uneconomical for a single user to have exclusive access to the machine. To keep costs down, multiple users used terminals to access a single mainframe, sharing time on the mainframe. One user's idle time will allow another to actively access the system. As the cost of computer systems decreased, the use of time-sharing of a central system faded. Human Computer Interaction includes two-time phases, System Response Time (SRT), the interval of time between user input and computer response, and User Response Time (URT), the time that elapses between computer response and user input.

Computer mediated task output has been shown to be substantially impacted by delays within each of these time intervals. The findings of studies looking into this issue indicate that delay effects are dependent on the task's complexity level or information processing requirements. The amount of time it takes to process the information associated with task decisions must be proportional to the amount of time it takes to make certain decisions. As the complexity of the task increases, machine-imposed delays can help the user perform better by relieving them of the time constraints that come with fast computer response times. The effect of such delays should be to encourage the user to spend more time contemplating the task at hand.

Models of Response-Time Impacts

Response time

The response time (speed with which an interface responds) has a significant impact on usability. If something happens fast enough, we will perceive it as being instant. When we must wait and are unable to do anything, time appears to slow down.

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The number of seconds it takes from the moment users initiate an activity until the computer presents results on the display. Number of seconds it takes from the moment a user initiates an action (e.g., by pressing a button or Enter) until the computer begins to present results on the display, printer, etc.

- The response commonly leads to the user formulating a new goal.
- Computer response times can be measured and/or predicted.

Users think time

The number of seconds the user thinks before entering the next action.

- Users think times are exceedingly difficult to measure or predict.

Simple model of response time

- Users (1) initiate, (2) wait for response, (3) watch results, (4) think for a while, and initiate again.

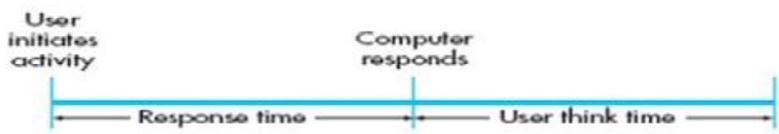

Fig. 13.1 *Simple model of response time*

More realistic model of response time

In more realistic model of response time people will use whatever, time they must plan.

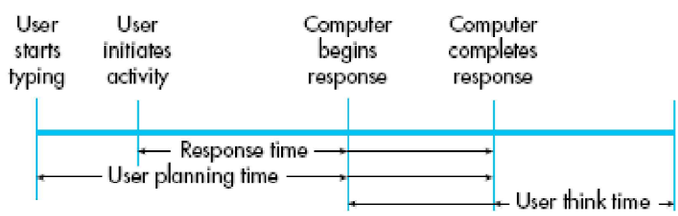

Fig. 13.2 *More realistic model of response time*

Preferred response time

For a given user and task, there is a preferred response time.

Table 13.2 *Preferred Response Time*

Long Response Time	Short Response Time
It led to wasted effort and more errors because the solution plan must be reviewed repeatedly.	It may generate a faster pace in which solution plans are prepared hastily and incompletely.
Long response time causes uneasiness because the penalty for error increases.	The user may pick up the pace of interface and fail to fully comprehend the presented materials in short response time.

Overall majority of users prefer rapid interactions; however, overall productivity depends on *interaction speed ,error rates , and ease of recovery from errors.* Long response times (>15 seconds) reduce efficiency by rising error rates and reducing customer satisfaction. Rapid response times (1 second or less) are preferable, but they can lead to more errors in complex tasks if the user does not take enough time to consider. The high cost of delivering fast response times, as well as the loss from increased errors, must be considered when determining the best speed.

Response-time choke

When the load is light and the potential output is high, a device is slowed down. It makes response times more consistent over time and through users, avoiding unrealistic expectations. Response time across Websites varies. It effects user interest and quality assessment.

13.4 DEALING WITH TIME DELAYS

The time delay between a user's initiation of a command on a computer and the system's completion and display of the result is known as the System Response Time (SRT). These times can range from milliseconds to minutes depending on numerous variables, including the complexity of the task and the processing power of the system. SRT is also a major source of frustration for computer users, and it can severely degrade the systems and different applications usability. Therefore, this temporal aspect of Human Computer Interaction (HCI) is an important component of a system's overall design.

Designers of Response Times and Display Rates in HCI Must Considered:

- Complex interaction of technical feasibility
- Cost
- Task complexity
- User expectations
- Speed of task performance
- Error rates
- Error handling procedures

Echo Delay

- Delay is an audio signal processing technique that records an input signal to a storage medium and then plays it back after a period. The delayed signal may be played back multiple times, or fed back into the recording, to create the sound of a repeating, decaying echo.
- Delay effects range from a subtle echo effect to a pronounced blending of previous sounds with new sounds. Delay effects can be created using tape

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loops, an approach developed in the 1940s and 1950s; analog effects units, which were introduced in the 1970s; digital effects pedals, introduced in 1984; and audio software plugins, developed in the 2000s.

Avoiding Delays

One must push for improved performance and reduced delays. Whenever possible, avoid delays. A lot of the most important ways of avoiding delay but it becomes costly.

To reduce delays following steps need to be taken:

- It is important to have good Database Analysts (DBAs) and other appropriate technical personnel on staff because it allows them to make crucial decisions about how to store, retrieve, and transfer data inside the system.
- Set good goals and objectives that follow human-centric best practices.
- Prefetch data using predictive analysis. Online charts, for example, display small bits of data in the same way that endless scrolling lists do, but they never show a spinning delay indicator. To prevent delays, they load the immediately adjacent maps that the user does not see in the viewport at first.
- Create your app or Website as a service rather than individual Websites. If the system has already retrieved information, making users wait three minutes for it will irritate them and cost them more money. Save the information for later use.

13.4.1 Blinking for Attention

Attention is taking possession by the mind in clear. The meaning is focalization, focus, and consciousness. It entails a separation from certain items to focus on others. Blinking is one of the techniques for getting the user's attention. The user's attention is quickly drawn to items flashing on the screen. This method can be upsetting and intrusive. Animation is often used to express the GUI's internal state, such as work in progress or general operation.

Use of Sound

In human-computer interaction audio provide a richer, more robust environment than the graphics. When the bandwidth of graphic information has been depleted, as is often the case with today's focus on graphic presentation, auditory input may provide additional information. Sounds render tasks simpler and more efficient by extending traditional interfaces in another dimension. Other studies have shown that sound can better reflect some forms of information than graphics or text. Furthermore, audio input can be used in conjunction with graphics and text to provide useful redundancy by reinforcing or reconfirming an idea in the user's mind. Obviously, sounds can be used to communicate details. This is useful not

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only for the blind, but for any program that requires the user's focus to be divided. Sound helps in getting attention of user.

- Attention: Sound, for example, may be used to draw the user's attention to a critical situation or the completion of a procedure.
- Status information: To convey status information, continuous background sounds can be used. Monitoring the progress of a procedure, for example.
- Confirmation: A sound that is associated with an action that is used to confirm that the action was completed. Associating a sound with deleting a file, for example.
- Navigation: Using changing sound to indicate where the user is in a system.

Preventing Errors

The most common use of friction in product design is to make it difficult to do anything by accident, which is a simple usability concept. Some dialogues can also require extra effort from the user, such as typing in a particular command, depending on the severity of the operation. This solution not only makes it more difficult to confirm deletion by mistake, but it also slows users down by forcing them to read the overlay message to fully comprehend what is going on.

Check Your Progress

5. Name the two-time phases human computer interaction includes.
6. What is known as response time choke?
7. Define the term echo delay.
8. List any one step to be taken to reduce delay.

13.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. There are two main components of information search:
   - Usability
   - Prototypes
2. A prototype is mainly used for testing, discovery, and communication. Its aim is to gather user feedback on design and provide it to designers.
3. The practise of developing software prototypes, or unfinished versions of the software programme being created, is known as software prototyping.
4. The benefit of prototyping is that users will provide useful input to the software designer and implementer early in the project.
5. Human computer interaction includes two-time phases, System Response Time (SRT), the interval of time between user input and computer response,

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and User Response Time (URT), the time that elapses between computer response and user input.

6. When the load is light and the potential output is high, a device is slowed down. It makes response times more consistent over time and through users, avoiding unrealistic expectations.
7. Delay is an audio signal processing technique that records an input signal to a storage medium and then plays it back after a period. The delayed signal may be played back multiple times, or fed back into the recording, to create the sound of a repeating, decaying echo.
8. It is important to have good Database Analysts (DBAs) and other appropriate technical personnel on staff because it allows them to make crucial decisions about how to store, retrieve, and transfer data inside the system.

13.6 SUMMARY

- Usability is a consistency metric that measures how convenient it is to use a user interface.
- During the design process, the term usability also applies to strategies for enhancing ease-of-use.
- Usability is a term used in user interface design to describe how well and easily a user can interact with a given interface.
- Usability encompasses several other terms, including learnability and usefulness.
- Usability is a term used to describe any programme or electronic system that requires human-machine interaction.
- A prototype is mainly used for testing, discovery, and communication. Its aim is to gather user feedback on design and provide it to designers.
- The primary function is that of a communicator, not precision or thoroughness.
- A prototype helps you imagine a concept and gives you an idea of how the app will look and function. It also helps in the definition of tasks, their flow, the system itself, and the screens that make up the interface.
- A prototype can have a lot of scope, with as many features as possible to show ideas and overall organisation, or it can have a lot of depth, with more information on a specific function or mission to concentrate on specific design aspects.
- A prototype, by definition, cannot be used to test all a system's features, only those that are significant in some way.
- A prototype, which is especially useful early in the design process, should be able to be quickly modified as testing is carried out.

- The fidelity of a prototype is defined by the accuracy and thoroughness with which it replicates a system's screens and user interaction.
- Computer networks used to be massive and costly, making it uneconomical for a single user to have exclusive access to the machine. To keep costs down, multiple users used terminals to access a single mainframe, sharing time on the mainframe.
- Human computer interaction includes two-time phases, System Response Time (SRT), the interval of time between user input and computer response, and User Response Time (URT), the time that elapses between computer response and user input.
- The response time (speed with which an interface responds) has a significant impact on usability. If something happens fast enough, we will perceive it as being instant.
- The time delay between a user's initiation of a command on a computer and the system's completion and display of the result is known as the System Response Time (SRT).
- SRT is also a major source of frustration for computer users, and it can severely degrade the systems and different applications usability.
- Delay is an audio signal processing technique that records an input signal to a storage medium and then plays it back after a period.
- The delayed signal may be played back multiple times, or fed back into the recording, to create the sound of a repeating, decaying echo.
- Attention is taking possession by the mind in clear. The meaning is focalization, focus, and consciousness. It entails a separation from certain items to focus on others. Blinking is one of the techniques for getting the user's attention.

13.7 KEY WORDS

- **Usability:** It is a consistency metric that measures how convenient it is to use a user interface.
- **Efficiency:** Users can perform tasks quickly through the easiest process. It answers the question how easily users can perform tasks once they have mastered the design.
- **Effectiveness and memorability:** It support users in completing actions accurately.
- **Error tolerance:** It supports a variety of user behaviours and only displays an error when something is wrong.

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- **Prototype:** A prototype is mainly used for testing, discovery, and communication. Its aim is to gather user feedback on design and provide it to designers.
- **Response time:** It has a significant impact on usability. If something happens fast enough, we will perceive it as being instant.
- **Users think time:** The number of seconds the user thinks before entering the next action.

13.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define the term usability.
2. What is the impact of business function in user interface design?
3. What are system training tools?
4. State the few applications where interaction speed influences the user interface design.
5. What are the needs for requirement analysis?
6. What are the design guidelines expected for user interface design?
7. What are the common usability problems?
8. Give any 2 applications which utilize the human interaction speed.

Long-Answer Questions

1. What is information research? Discuss its components in brief.
2. Elaborate on the areas where usability concept can be used with the help of suitable examples.
3. What are prototypes? Discuss about the benefits of prototyping.
4. Discuss about system response time and its models in brief with the help of appropriate examples.
5. Elaborate on how to deal with time delays using realistic examples.

13.9 FURTHER READINGS

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UNIT 14 USABILITY AND PROTOTYPES USABILITY

Structure

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14.0 INTRODUCTION

In Human Computer Interaction (HCI) and computer science, usability studies the elegance and clarity with which the interaction with a computer program or a web site or web usability is designed. Usability considers user satisfaction and utility as quality components, and aims to improve user experience through iterative design.

Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In software engineering, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use. A usability study may be conducted as a primary job function by a usability analyst or as a secondary job function by designers, technical writers, marketing personnel, and others. Usability includes methods of measuring usability, such as needs analysis and the study of the principles behind an object's perceived efficiency. The usability evaluation methods involve observation of users by an experimenter, or the testing and evaluation of a program by an expert reviewer. They provide more quantitative data as tasks can be timed and recorded. Heuristic evaluation is a usability engineering method for finding and assessing usability problems in a user interface

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design as part of an iterative design process. It involves having a small set of evaluators examining the interface and using recognized usability principles, the 'Heuristics'.

The Facade pattern is a software-design pattern commonly used in Object-Oriented Programming (OOP). Analogous to a facade in architecture, a Facade is an object that serves as a front-facing interface masking more complex underlying or structural code. The 'Façade' design pattern is one of the twenty-three well-known Gang of Four (GoF) design patterns that describe how to solve recurring design problems to design flexible and reusable object-oriented software, that is, objects that are easier to implement, change, test, and reuse.

A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users. A prototype can be anything from paper drawings (low-fidelity) to something that allows click-through of a few pieces of content to a fully functioning site (high-fidelity). In Human Computer Interaction (HCI), paper prototyping is a widely used method in the user-centred design process, a process that helps developers to create software that meets the user's expectations and needs, especially for designing and testing user interfaces.

Prototype-based programming is a style of Object-Oriented Programming (OOP) in which behaviour reuse (known as inheritance) is performed via a process of reusing existing objects that serve as prototypes. This model can also be known as prototypal, prototype-oriented, classless, or instance-based programming. The first Prototype-Oriented Programming (POP) language was 'Self', developed by David Ungar and Randall Smith in the mid-1980s to research topics in object-oriented language design. In prototype-based languages there are no explicit classes. Objects inherit directly from other objects through a prototype property.

In this unit, you will study about the usability and prototypes usability, purpose of usability, importance of usability, usability testing, prototypes, hand sketches and scenarios, interactive paper prototypes, programme facades, and prototype-oriented languages.

14.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the significant features of usability
- Explain the concept of prototypes usability
- Define the purpose and importance of usability
- Know how usability testing is done

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- Explain the concept of prototypes
- Elaborate on hand sketches and interactive paper prototypes
- Describe the importance of programme facades
- Discuss about the prototype-oriented languages

14.2 USABILITY

Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In software engineering, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.

The object of use can be a software application, website, book, tool, machine, process, vehicle, or anything a human interacts with. A usability study may be conducted as a primary job function by a usability analyst or as a secondary job function by designers, technical writers, marketing personnel, and others. It is widely used in consumer electronics, communication, and knowledge transfer objects, such as a cookbook, a document or online help, and mechanical objects, such as a door handle or a hammer.

Usability includes methods of **measuring usability**, such as needs analysis and the study of the principles behind an object's perceived efficiency. In Human Computer Interaction (HCI) and computer science, usability studies the elegance and clarity with which the interaction with a computer program or a web site or web usability is designed. Usability considers user satisfaction and utility as quality components, and aims to improve user experience through iterative design.

The primary notion of usability is that an object designed with a generalized users' psychology and physiology, for example:

- More efficient to use—takes less time to accomplish a particular task.
- Easier to learn—operation can be learned by observing the object.
- More satisfying to use.

Complex computer systems find their way into everyday life, and at the same time the market is saturated with competing brands. This has made usability more popular and widely recognized in recent years, as companies see the benefits of researching and developing their products with user-oriented methods instead of technology-oriented methods. By understanding and researching the interaction between product and user, the usability expert can also provide insight that is unattainable by traditional company-oriented market research. For example, after observing and interviewing users, the usability expert may identify needed functionality or design flaws that were not anticipated. A method called contextual inquiry does this in the naturally occurring context of the users own environment.

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In the user-centred design paradigm, the product is designed with its intended users in mind at all times. In the user-driven or participatory design paradigm, some of the users become actual or de facto members of the design team.

The term **user friendly** is often used as a synonym for usable, though it may also refer to accessibility. Usability describes the quality of user experience across websites, software, products, and environments. There is no consensus about the relation of the terms ergonomics (or human factors) and usability. Some think of usability as the software specialization of the larger topic of ergonomics. Others view these topics as tangential, with ergonomics focusing on physiological matters (e.g., turning a door handle) and usability focusing on psychological matters (e.g., recognizing that a door can be opened by turning its handle). Usability is also important in website development (web usability).

According to Jakob Nielsen, "Studies of user behaviour on the Web find a low tolerance for difficult designs or slow sites. People do not want to wait and they do not want to learn how to use a home page. There is no such thing as a training class or a manual for a Web site. People have to be able to grasp the functioning of the site immediately after scanning the home page—for a few seconds at most". Otherwise, most casual users simply leave the site and browse elsewhere.

Usability can also include the concept of prototypicality, which is how much a particular thing conforms to the expected shared norm, for instance, in website design, users prefer sites that conform to recognised design norms.

Definition

International Organization for Standardization (ISO) defines usability as, "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". The word '**Usability**' also refers to methods for improving ease-of-use during the design process. Usability consultant Jakob Nielsen and computer science professor Ben Shneiderman have written (independently) about a framework of system acceptability, where usability is a part of 'Usefulness' and includes the following:

Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design?

Efficiency: Once users have learned the design, how quickly can they perform tasks?

Memorability: When users return to the design after a period of not using it, how easily can they re-establish proficiency?

Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?

Satisfaction: How pleasant is it to use the design?

Usability is often associated with the functionalities of the product, in addition to being solely a characteristic of the user interface, for example, in the context of

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mainstream consumer products, an automobile lacking a reverse gear could be considered unusable according to the former view, and lacking in utility according to the latter view. When evaluating **User Interfaces (UIs)** for usability, the definition can be as simple as, "The perception of a target user of the effectiveness (fit for purpose) and efficiency (work or time required to use) of the Interface". Each component may be measured subjectively against criteria, for example "Principles of User Interface Design", to provide a metric, often expressed as a percentage. It is important to distinguish between usability testing and usability engineering.

Usability Testing (UT) is the measurement of ease of use of a product or piece of software. In contrast, **Usability Engineering (UE)** is the research and design process that ensures a product with good usability. Usability is a non-functional requirement. As with other non-functional requirements, usability cannot be directly measured but must be quantified by means of indirect measures or attributes, such as the number of reported problems with ease-of-use of a system.

Intuitive Interfaces

The term **intuitive** is often listed as a desirable trait in usable interfaces, often used as a synonym for learnable. Some experts, such as Jef Raskin have discouraged using this term in user interface design, claiming that easy to use interfaces are often easy because of the user's exposure to previous similar systems, thus the term 'Familiar' should be preferred. As an example, two vertical lines **"| |"** on media player buttons do not intuitively mean 'Pause' —they do so by convention. Aiming for 'Intuitive' interfaces (based on reusing existing skills with interaction systems) could lead designers to discard a better design solution only because it would require a novel approach. This position is sometimes illustrated with the remark that, "The only intuitive interface is the nipple; everything else is learned". Bruce Tognazzini even denies the existence of 'Intuitive' interfaces, since such interfaces must be able to intuit, i.e., "Perceive the patterns of the user's behaviour and draw inferences". Instead, he advocates the term 'Intuitable', i.e., that users could intuit the workings of an application by seeing it and using it.

ISO Standards

Following are the ISO Standards for usability methods supporting human-centred design.

ISO/TR 16982:2002 Standard: ISO/TR 16982:2002 "Ergonomics of Human System Interaction (HIS)—Usability methods supporting human centred design" is an International Standards Organization (ISO) standard that provides information on human centred usability methods that can be used for design and evaluation. It details the advantages, disadvantages, and other factors relevant to using each usability method. It explains the implications of the stage of the life cycle and the individual project characteristics for the selection of usability methods and provides examples of usability methods in context. The main users of ISO/TR 16982:2002 are project managers. It therefore addresses technical human factors and ergonomics issues only to the extent necessary to allow managers to understand their relevance and importance in the design process as a whole. The guidance in

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ISO/TR 16982:2002 can be tailored for specific design situations by using the lists of issues characterizing the context of use of the product to be delivered. Selection of appropriate usability methods should also take account of the relevant life-cycle process. ISO/TR 16982:2002 is restricted to methods that are widely used by usability specialists and project managers. It does not specify the details of how to implement or carry out the usability methods described.

ISO 9241 Standard: ISO 9241 is a multi-part standard that covers a number of aspects of people working with computers. Although originally titled Ergonomic requirements for office work with Visual Display Terminals (VDTs), it has been retitled to the more generic Ergonomics of Human System Interaction. As part of this change, ISO is renumbering some parts of the standard so that it can cover more topics, for example tactile and haptic interaction. The first part to be renumbered was part 10 in 2006, now part 110.

IEC 62366: IEC 62366-1:2015 + COR1:2016 & IEC/TR 62366-2 provide guidance on usability engineering specific to a medical device.

14.2.1 Importance of Usability

Following are the key benefits or importance of usability:

- Higher Revenues through Increased Sales
- Increased User Efficiency and User Satisfaction
- Reduced Development Costs
- Reduced Support Costs

Corporate Integration

An increase in usability generally positively affects several facets of a company's output quality. In particular, the benefits or importance has the following common areas:

- Increased Productivity
- Decreased Training and Support Costs
- Increased Sales and Revenues
- Reduced Development Time and Costs
- Reduced Maintenance Costs
- Increased Customer Satisfaction

Increased usability in the workplace fosters several responses from employees: "Workers who enjoy their work do it better, stay longer in the face of temptation, and contribute ideas and enthusiasm to the evolution of enhanced productivity". To create standards, companies often implement experimental design techniques that create baseline levels. Areas of concern in an office environment include (though are not necessarily limited to):

- Working Posture
- Design of Workstation Furniture

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- Screen Displays
- Input Devices
- Organization Issues
- Office Environment
- Software Interface

By working to improve said factors, corporations can achieve their goals of increased output at lower costs, while potentially creating optimal levels of customer satisfaction. There are numerous reasons why each of these factors correlates to overall improvement. For example, making software user interfaces easier to understand reduces the need for extensive training. The improved interface tends to lower the time needed to perform tasks, and so would both raise the productivity levels for employees and reduce development time (and thus costs). Each of the aforementioned factors are not mutually exclusive; rather they should be understood to work in conjunction to form the overall workplace environment. In the 2010s, usability is recognized as an important software quality attribute, making its place among more traditional attributes, such as performance, robustness and aesthetic appearance.

There is some resistance to integrating usability work in organisations. Usability is seen as a vague concept, it is difficult to measure and other areas are prioritised when IT projects run out of time or money.

14.2.2 Designing for Usability

Any system or device designed for use by people should be easy to use, easy to learn, easy to remember (the instructions), and helpful to users. John Gould and Clayton Lewis recommend that designers striving for usability follow the following three design principles:

- Early focus on end users and the tasks they need the system/device to do.
- Empirical measurement using quantitative or qualitative measures.
- Iterative design, in which the designers work in a series of stages, improving the design each time.

Early Focus on Users and Tasks

The design team should be user-driven and it should be in direct contact with potential users. Several evaluation methods, including personas, cognitive modeling, inspection, inquiry, prototyping, and testing methods may contribute to understanding potential users and their perceptions of how well the product or process works. Usability considerations, such as who the users are and their experience with similar systems must be examined. As part of understanding users, this knowledge must "...be played against the tasks that the users will be expected to perform". This includes the analysis of what tasks the users will perform, which are most important, and what decisions the users will make while using your system. Designers must understand how cognitive and emotional characteristics of users

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will relate to a proposed system. One way to stress the importance of these issues in the designers' minds is to use personas, which are made-up representative users. Another more expensive but more insightful method is to have a panel of potential users work closely with the design team from the early stages.

Empirical Measurement

Test the system early on, and test the system on real users using behavioural measurements. This includes testing the system for both learnability and usability. It is important in this stage to use quantitative usability specifications, such as time and errors to complete tasks and number of users to test, as well as examine performance and attitudes of the users testing the system. Finally, "Reviewing or Demonstrating" a system before the user tests it can result in misleading results. The emphasis of empirical measurement is on measurement, both informal and formal, which can be carried out through a variety of evaluation methods.

Iterative Design

Iterative design is a design methodology based on a cyclic process of prototyping, testing, analysing, and refining a product or process. Based on the results of testing the most recent iteration of a design, changes and refinements are made. This process is intended to ultimately improve the quality and functionality of a design. In iterative design, interaction with the designed system is used as a form of research for informing and evolving a project, as successive versions, or iterations of a design are implemented.

The key requirements for iterative design are identification of required changes, an ability to make changes, and a willingness to make changes. When a problem is encountered, there is no set method to determine the correct solution. Rather, there are empirical methods that can be used during system development or after the system is delivered, usually a more inopportune time. Ultimately, iterative design works towards meeting goals, such as making the system user friendly, easy to use, easy to operate, simple, etc.

14.2.3 Evaluation Methods

There are a variety of usability evaluation methods. Certain methods use data from users, while others rely on usability experts. There are usability evaluation methods for all stages of design and development, from product definition to final design modifications. When choosing a method, consider cost, time constraints, and appropriateness. Usability methods can be further classified into the subcategories defined below.

1. Cognitive Modeling Methods

Cognitive modeling involves creating a computational model to estimate how long it takes people to perform a given task. Models are based on psychological principles and experimental studies to determine times for cognitive processing and motor movements. Cognitive models can be used to improve user interfaces or predict problem errors and pitfalls during the design process. A few examples of cognitive models include:

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Parallel Design: With parallel design, several people create an initial design from the same set of requirements. Each person works independently, and when finished, shares concepts with the group. The design team considers each solution, and each designer uses the best ideas to further improve their own solution. This process helps generate many different, diverse ideas, and ensures that the best ideas from each design are integrated into the final concept. This process can be repeated several times until the team is satisfied with the final concept.

GOMS: GOMS stands for Goals, Operator, Methods, and Selection Rules. It is a family of techniques that analyses the user complexity of interactive systems. Goals are what the user must accomplish. An operator is an action performed in pursuit of a goal. A method is a sequence of operators that accomplish a goal. Selection rules specify which method satisfies a given goal, based on context.

Human Processor Model: Sometimes it is useful to break a task down and analyse each individual aspect separately. This helps the tester locate specific areas for improvement. To do this, it is necessary to understand how the human brain processes information. A model of the human processor is shown below in Figure 14.1.

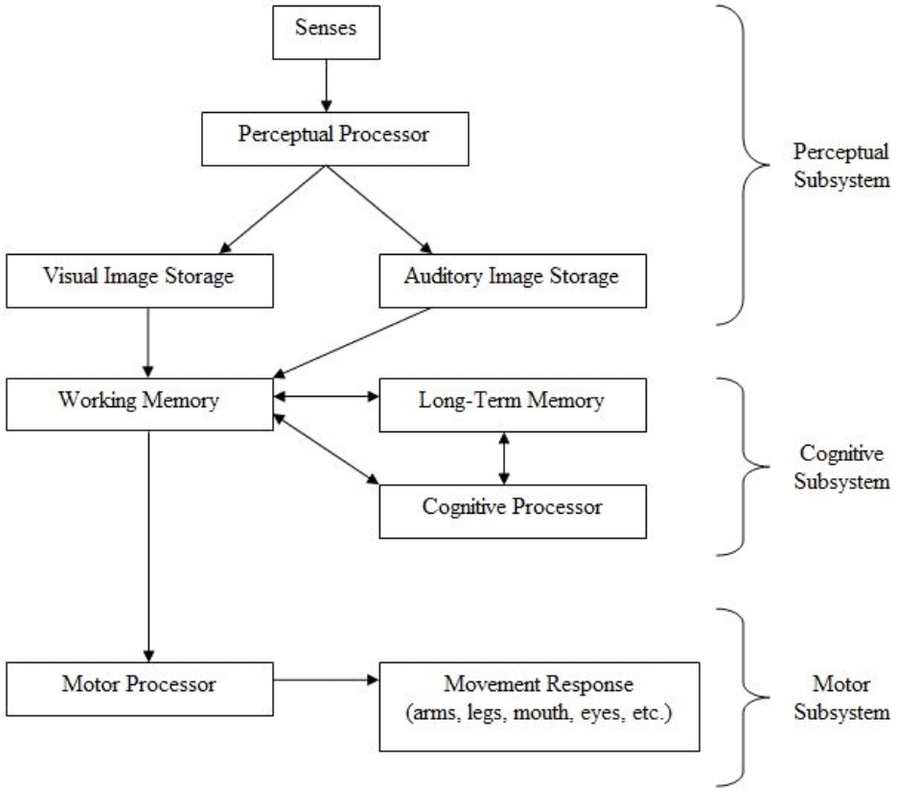

Fig. 14.1 *Model of the Human Processor*

Many studies have been done to estimate the cycle times, decay times, and capacities of each of these processors. Variables that affect these can include

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subject age, aptitudes, ability, and the surrounding environment. For a younger adult, reasonable estimates are as follows:

Parameter	Mean	Range
Eye Movement Time	230 ms	70–700 ms
Decay Half-Life of Visual Image Storage	200 ms	90–1000 ms
Perceptual Processor Cycle Time	100 ms	50–200 ms
Cognitive Processor Cycle Time	70 ms	25–170 ms
Motor Processor Cycle Time	70 ms	30–100 ms
Effective Working Memory Capacity	2 Items	2–3 Items

Long-term memory is believed to have an infinite capacity and decay time.

Keystroke Level Modeling: Keystroke level modeling is essentially a less comprehensive version of GOMS that makes simplifying assumptions in order to reduce calculation time and complexity.

2. Inspection Methods

These usability evaluation methods involve observation of users by an experimenter, or the testing and evaluation of a program by an expert reviewer. They provide more quantitative data as tasks can be timed and recorded.

Card Sorts: Card sorting is a way to involve users in grouping information for a website's usability review. Participants in a card sorting session are asked to organize the content from a Web site in a way that makes sense to them. Participants review items from a Web site and then group these items into categories. Card sorting helps to learn how users think about the content and how they would organize the information on the Web site. Card sorting helps to build the structure for a Web site, decide what to put on the home page, and label the home page categories. It also helps to ensure that information is organized on the site in a way that is logical to users.

Tree Tests: Tree testing is a way to evaluate the effectiveness of a website's top-down organization. Participants are given 'Find It' tasks, then asked to drill down through successive text lists of topics and subtopics to find a suitable answer. Tree testing evaluates the findability and labelling of topics in a site, separate from its navigation controls or visual design.

Ethnography: Ethnographic analysis is derived from anthropology. Field observations are taken at a site of a possible user, which track the artefacts of work, such as Post-It notes, items on desktop, shortcuts, and items in trash bins. These observations also gather the sequence of work and interruptions that determine the user's typical day.

Heuristic Evaluation: Heuristic evaluation is a usability engineering method for finding and assessing usability problems in a user interface design as part of an iterative design process. It involves having a small set of evaluators examining the interface and using recognized usability principles, the 'Heuristics'. It is the most popular of the usability inspection methods, as it is quick, cheap, and easy. Heuristic

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evaluation was developed to aid in the design of computer user interface design. It relies on expert reviewers to discover usability problems and then categorise and rate them by a set of principles, heuristics. It is widely used based on its speed and cost-effectiveness. Jakob Nielsen's list of ten heuristics is the most commonly used in industry. There are ten general principles for user interface design. They are called 'Heuristics' because they are more in the nature of rules of thumb than specific usability guidelines. These include,

- **Visibility of System Status:** The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- **Match between System and the Real World:** The system should speak the users' language, with words, phrases and concepts familiar to the user rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- **User Control and Freedom:** Users often choose system functions by mistake and will need a clearly marked 'Emergency Exit' to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
- **Consistency and Standards:** Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- **Error Prevention:** Even better than good error messages is a careful design that prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.
- **Recognition Rather Than Recall:** Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
- **Flexibility and Efficiency of Use:** Accelerators, unseen by the novice user, may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- **Aesthetic and Minimalist Design:** Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
- **Help Users Recognize, Diagnose and Recover from Errors:** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

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- **Help and Documentation:** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Thus, by determining which guidelines are violated, the usability of a device can be determined.

Usability Inspection: Usability inspection is a review of a system based on a set of guidelines. The review is conducted by a group of experts who are deeply familiar with the concepts of usability in design. The experts focus on a list of areas in design that have been shown to be troublesome for users.

Pluralistic Inspection: Pluralistic inspections are meetings where users, developers, and human factors people meet together to discuss and evaluate step by step of a task scenario. As more people inspect the scenario for problems, the higher the probability to find problems. In addition, the more interaction in the team, the faster the usability issues are resolved.

Consistency Inspection: In consistency inspection, expert designers review products or projects to ensure consistency across multiple products to look if it does things in the same way as their own designs.

Activity Analysis: Activity analysis is a usability method used in preliminary stages of development to get a sense of situation. It involves an investigator observing users as they work in the field. Also referred to as user observation, it is useful for specifying user requirements and studying currently used tasks and subtasks. The data collected are qualitative and useful for defining the problem. It should be used when you wish to frame what is needed, or "What do we want to know?"

3. Inquiry Methods

The following usability evaluation methods involve collecting qualitative data from users. Although the data collected is subjective, it provides valuable information on what the user wants.

Task Analysis: Task analysis means learning about users' goals and users' ways of working. Task analysis can also mean figuring out what more specific tasks users must do to meet those goals and what steps they must take to accomplish those tasks. Along with user and task analysis, a third analysis is often used, understanding users' environments (physical, social, cultural, and technological environments).

Focus Groups: A focus group is a focused discussion where a moderator leads a group of participants through a set of questions on a particular topic. Although typically used as a marketing tool, 'Focus Groups' are sometimes used to evaluate usability. Used in the product definition stage, a group of 6 to 10 users are gathered to discuss what they desire in a product. An experienced focus group facilitator is hired to guide the discussion to areas of interest for the developers.

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Focus groups are typically videotaped to help get verbatim quotes, and clips are often used to summarize opinions. The data gathered is not usually quantitative, but can help get an idea of a target group's opinion.

Questionnaires/Surveys: Surveys have the advantages of being inexpensive, require no testing equipment, and results reflect the users' opinions. When written carefully and given to actual users who have experience with the product and knowledge of design, surveys provide useful feedback on the strong and weak areas of the usability of a design. This is a very common method and often does not appear to be a survey, but just a warranty card.

4. Prototyping Methods

It is often very difficult for designers to conduct usability tests with the exact system being designed. Cost constraints, size, and design constraints usually lead the designer to creating a prototype of the system. Instead of creating the complete final system, the designer may test different sections of the system, thus making several small models of each component of the system. Prototyping is an attitude and an output, as it is a process for generating and reflecting on tangible ideas by allowing failure to occur early. Prototyping helps people to see what could be of communicating a shared vision, and of giving shape to the future. The types of usability prototypes may vary from using paper models, index cards, hand drawn models, or storyboards. Prototypes are able to be modified quickly, often are faster and easier to create with less time invested by designers and are more apt to change design; although sometimes are not an adequate representation of the whole system, are often not durable and testing results may not be parallel to those of the actual system.

Toolkit Approach: This toolkit is a wide library of methods that used the traditional programming language and it is primarily developed for computer programmers. The code created for testing in the tool kit approach can be used in the final product. However, to get the highest benefit from the tool, the user must be an expert programmer.

Parts Kit Approach: The two elements of this approach include a parts library and a method used for identifying the connection between the parts. This approach can be used by almost anyone and it is a great asset for designers with repetitive tasks.

Animation Language Metaphor: This approach is a combination of the toolkit approach and the part kit approach. Both the dialogue designers and the programmers are able to interact with this prototyping tool.

Rapid Prototyping: Rapid prototyping is a method used in early stages of development to validate and refine the usability of a system. It can be used to quickly and cheaply evaluate user-interface designs without the need for an expensive working model. This can help remove hesitation to change the design, since it is implemented before any real programming begins. One such method of rapid prototyping is paper prototyping.

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14.2.4 Usability Testing

These usability evaluation methods involve testing of subjects for the most quantitative data. Usually recorded on video, they provide task completion time and allow for observation of attitude. Regardless to how carefully a system is designed, all theories must be tested using usability tests. Usability tests involve typical users using the system (or product) in a realistic environment. Observation of the user's behaviour, emotions, and difficulties while performing different tasks, often identify areas of improvement for the system.

Metrics: While conducting usability tests, designers must use usability metrics to identify what it is they are going to measure, or the usability metrics. These metrics are often variable, and change in conjunction with the scope and goals of the project. The number of subjects being tested can also affect usability metrics, as it is often easier to focus on specific demographics. Qualitative design phases, such as general usability (can the task be accomplished?), and user satisfaction are also typically done with smaller groups of subjects. Using inexpensive prototypes on small user groups provides more detailed information, because of the more interactive atmosphere, and the designer's ability to focus more on the individual user.

As the designs become more complex, the testing must become more formalized. Testing equipment will become more sophisticated and testing metrics become more quantitative. With a more refined prototype, designers often test effectiveness, efficiency, and subjective satisfaction, by asking the user to complete various tasks. These categories are measured by the percent that complete the task, how long it takes to complete the tasks, ratios of success to failure to complete the task, time spent on errors, the number of errors, rating scale of satisfactions, number of times user seems frustrated, etc. Additional observations of the users give designers insight on navigation difficulties, controls, conceptual models, etc. The ultimate goal of analysing these metrics is to find/create a prototype design that users like and use to successfully perform given tasks. After conducting usability tests, it is important for a designer to record what was observed, in addition to why such behaviour occurred and modify the model according to the results. Often it is quite difficult to distinguish the source of the design errors, and what the user did wrong. However, effective usability tests will not generate a solution to the problems, but provide modified design guidelines for continued testing.

Remote Usability Testing: Remote usability testing, also known as unmoderated or asynchronous usability testing, involves the use of a specially modified online survey, allowing the quantification of user testing studies by providing the ability to generate large sample sizes, or a deep qualitative analysis without the need for dedicated facilities. Additionally, this style of user testing also provides an opportunity to segment feedback by demographic, attitudinal and behavioural type. The tests are carried out in the user's own environment (rather than labs) helping further simulate real-life scenario testing. This approach also provides an approach

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to easily solicit feedback from users in remote areas. There are two types, 'Quantitative' or 'Qualitative'. Quantitative use large sample sized and task based surveys. These types of studies are useful for validating suspected usability issues. Qualitative studies are best used as exploratory research, in small sample sizes but frequent, even daily iterations. Qualitative usually allows for observing respondent's screens and verbal think aloud commentary (Screen Recording Video, SRV), and for a richer level of insight also include the webcam view of the respondent (Video-in-Video, ViV, sometimes referred to as Picture-in-Picture, PiP).

Remote Usability Testing for Mobile Devices: The growth in mobile and associated platforms and services, for example 'Mobile Gaming' has experienced 20x growth in 2010-2012, has generated the requirement for unmoderated remote usability testing on mobile devices, both for websites but especially for app interactions. One methodology consists of shipping cameras and special camera holding fixtures to dedicated testers, and having them record the screens of the mobile smart-phone or tablet device, usually using an HD (High Density) camera. A drawback of this approach is that the finger movements of the respondent can obscure the view of the screen, in addition to the bias and logistical issues inherent in shipping special hardware to selected respondents. A newer approach uses a wireless projection of the mobile device screen onto the computer desktop screen of the respondent, who can then be recorded through their webcam, and thus a combined Video-in-Video (ViV) view of the participant and the screen interactions viewed simultaneously while incorporating the verbal think aloud commentary of the respondents.

Thinking Aloud: The 'Think Aloud' protocol is a method of gathering data that is used in both usability and psychology studies. It involves getting a user to verbalize their thought processes, i.e., expressing their opinions, thoughts, anticipations, and actions, as they perform a task or set of tasks. As a widespread method of usability testing, think aloud provides the researchers with the ability to discover what user really think during task performance and completion. Often an instructor is present to prompt the user into being more vocal as they work. Similar to the 'Subjects-in-Tandem' method, it is useful in pinpointing problems and is relatively simple to set up. Additionally, it can provide insight into the user's attitude, which cannot usually be discerned from a survey or questionnaire.

RITE Method: Rapid Iterative Testing and Evaluation (RITE) is an iterative usability method similar to traditional usability testing. The tester and team must define a target population for testing, schedule participants to come into the lab, decide on how the user's behaviours will be measured, construct a test script and have participants engage in a verbal protocol, for example think aloud. However it differs from these methods in that it advocates that changes to the user interface are made as soon as a problem is identified and a solution is perfect. Sometimes this can occur after observing as few as single or one participant. Once the data for a participant has been collected the usability engineer and team decide if they

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will be making any changes to the prototype prior to the next participant. The changed interface is then tested with the remaining users.

Subjects-In-Tandem or Co-Discovery: Subjects-in-tandem, also called co-discovery, is the pairing of subjects in a usability test to gather important information on the ease of use of a product. Subjects tend to discuss the tasks they have to accomplish out loud and through these discussions observers learn where the problem areas of a design are. To encourage co-operative problem-solving between the two subjects, and the attendant discussions leading to it, the tests can be designed to make the subjects dependent on each other by assigning them complementary areas of responsibility, for example for testing of software, one subject may be put in charge of the mouse and the other of the keyboard.

Component-Based Usability Testing: Component-based usability testing is an approach which aims to test the usability of elementary units of an interaction system, referred to as interaction components. The approach includes component-specific quantitative measures based on user interaction recorded in log files, and component-based usability questionnaires.

Cognitive Walk Through: Cognitive walkthrough is a method of evaluating the user interaction of a working prototype or final product. It is used to evaluate the system's ease of learning. Cognitive walk through is useful to understand the user's thought processes and decision-making when interacting with a system, especially for first-time or infrequent users.

Benchmarking: Benchmarking creates standardized test materials for a specific type of design. Following four key characteristics are considered when establishing a benchmark:

- Time to do the Core Task.
- Time to Fix Errors.
- Time to Learn Applications.
- Functionality of the System.

Once there is a benchmark, other designs can be compared to it to determine the usability of the system. Many of the common objectives of usability studies, such as trying to understand user behaviour or exploring alternative designs, must be earmarked. Unlike many other usability methods or types of labs studies, benchmark studies more closely resemble true experimental psychology lab studies, with greater attention to detail on methodology, study protocol and data analysis.

Meta-Analysis: Meta-analysis is a statistical procedure to combine results across studies to integrate the findings. This phrase was coined in 1976 as a quantitative literature review. This type of evaluation is very powerful for determining the usability of a device because it combines multiple studies to provide very accurate quantitative support.

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Persona: Personas are fictitious characters created to represent a site or product's different user types and their associated demographics and technographics. Alan Cooper introduced the concept of using personas as a part of interactive design in 1998 in his book, "*The Inmates Are Running the Asylum*", but had used this concept since as early as 1975. Personas are a usability evaluation method that can be used at various design stages. The most typical time to create personas is at the beginning of designing so that designers have a tangible idea of who the users of their product will be. Personas are the archetypes that represent actual groups of users and their needs, which can be a general description of person, context, or usage scenario. This technique turns marketing data on target user population into a few physical concepts of users to create empathy among the design team, with the final aim of tailoring a product more closely to how the personas will use it. To gather the marketing data that personas require, several tools can be used, including online surveys, web analytics, customer feedback forms, and usability tests, and interviews with customer-service representatives.

14.3 PROTOTYPES

A **prototype** is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users. Prototyping serves to provide specifications for a real, working system rather than a theoretical one. In some design workflow models, creating a prototype is the step between the formalization and the evaluation of a concept or notion.

A prototype can also mean a typical example of something, such as in the use of the derivation 'Prototypical'. This is a useful term in identifying objects, behaviours and concepts which are considered the accepted norm and is analogous with terms, such as stereotypes and archetypes.

The word prototype derives from the Greek word 'Prototypon' which means 'Primitive Form', neutral of 'Prototypos', 'Original, Primitive', from 'Protos', 'First' and 'Typos', 'Impression'.

Fundamentally, a prototype is a draft version of a product that allows the user to explore the ideas and show the intention behind a feature or the overall design concept to users before investing time and money into development. A prototype can be anything from paper drawings (low-fidelity) to something that allows click-through of a few pieces of content to a fully functioning site (high-fidelity).

Software Prototyping

Software prototyping is the activity of creating prototypes of software applications, i.e., incomplete versions of the software program being developed. It is an activity

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that can occur in software development and is comparable to prototyping as known from other fields, such as mechanical engineering or manufacturing. A prototype typically simulates only a few aspects of, and may be completely different from, the final product.

Software prototyping has several benefits, namely the software designer and implementer can get valuable feedback from the users early in the project. The client and the contractor can compare if the software made matches the software specification, according to which the software program is built. It also allows the software engineer some insight into the accuracy of initial project estimates and whether the deadlines and milestones proposed can be successfully materialised.

Types of Prototypes

Prototypes explore following different aspects of an intended design:

- A proof-of-principle prototype serves to verify some key functional aspects of the intended design, but usually does not have all the functionality of the final product.
- A working prototype represents all or nearly all of the functionality of the final product.
- A visual prototype represents the size and appearance, but not the functionality, of the intended design. A form study prototype is a preliminary type of visual prototype in which the geometric features of a design are emphasized, with less concern for color, texture, or other aspects of the final appearance.
- A user experience prototype represents enough of the appearance and function of the product that it can be used for user research.
- A functional prototype captures both function and appearance of the intended design, though it may be created with different techniques and even different scale from final design.
- A paper prototype is a printed or hand-drawn representation of the user interface of a software product. Such prototypes are commonly used for early testing of a software design, and can be part of a software walkthrough to confirm design decisions before more costly levels of design effort are expended.

Benefits of Prototypes

The benefit or importance of prototype is that it is less expensive to change a product early in the development process than to make change once the site is developed. Therefore, the software developer/designer should consider building prototypes early in the process. Prototyping permits the software developer/designer to gather feedback from users while they are still planning and designing the specific Web site.

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High-Fidelity and Low-Fidelity Prototyping

There is an on-going debate about using the low-fidelity versus high-fidelity prototyping and how much a prototype should resemble the final version of the specified design. Both have been found to be basically equivalent in finding usability issues (Walker *et al*., 2002).

Low-Fidelity Prototypes: Low-fidelity prototypes are often paper-based and do not allow user interactions. They range from a series of hand-drawn mock-ups to printouts. In theory, low-fidelity sketches are quicker to create. Low-fidelity prototypes are helpful in enabling early visualization of alternative design solutions, which helps provoke innovation and improvement. An additional advantage to this approach is that when using rough sketches, users may feel more comfortable suggesting changes.

High-Fidelity Prototypes: High-fidelity prototypes are computer-based, and usually allow realistic (mouse-keyboard) user interactions. High-fidelity prototypes take software developer/designer as close as possible to a true representation of the user interface. Consequently, the high-fidelity prototypes are assumed to be much more effective in collecting true human performance data, for example time to complete a task, and in demonstrating actual products to clients, management, and others.

14.3.1 Hand Sketches and Scenarios

Sketching is one of the earliest forms of prototyping that can be used. It requires very little effort and does not necessarily rely on artistic levels of drawing skill to prove useful, and therein lies its value. Hand sketches can be used to illustrate the concept and ideas for introducing them into the real world, even the simplest and crudest of sketches can easily achieve that.

Hand sketching is the effective way for conveying the design specifications in a timely and cost-efficient manner.

Bill Buxton, a Canadian pioneer in the Human Computer Interaction (HCI) field and a principal designer at Microsoft Research, considers software development lacks a "Design Process" that helps UX designers gain clarity about their design decisions before building a system. With this in mind, Buxton wrote,

> "… there are techniques and processes whereby we can put experience front and centre in design. My belief is that the basis for doing so lies in extending the traditional practice of sketching." – Bill Buxton

Sketching is a distinctive and typical form of drawing which are used by the designers in order to propose, explore, refine and communicate the basic concept and ideas.

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Advantages of Hand Sketches

According to Greenberg *et al*., more particularly the sketches can assist in the design process in the following ways:

- Think more openly and creatively about the ideas.
- Create abundant ideas without worrying about their quality.
- Invent and explore concepts by being able to record ideas quickly.
- Record ideas that come across.
- Discuss, critique, and share ideas with others.
- Choose ideas worth pursuing.
- Archive the ideas for later reflection.
- Have fun creating while designing.

Sketches must rely on the written word for conveying their meaning appropriately, i.e., the sketches and the accompanying text must communicate the entire design rationale perfectly. Following elements help in drawing and explaining the hand sketches and the objects and actions they represent.

Annotations: The annotations are names, labels and explanations positioned next to different fragments of a sketch for expanding and specifying the meaning of any element depicted in the sketch. Draw and connect annotations to different elements in the sketch using arrows, braces, numbering and spatial proximity. Write each annotation using specific different colour that contrasts with the sketch proper.

Arrows: Apart from pointing and connecting to specific elements in a sketch, use arrows to illustrate interaction flow, a sequence of events, movement and direction.

Notes: Any text, long or short, that provides additional insight into the sketch is referred as a note. Use notes to,

- Provide detailed explanation of the action or sequence illustrated.
- Describe an idea derived from an illustration.
- List unresolved issues.
- Explore design elements not depicted in the sketch.
- Clarify the purpose of each element that is specified in the sketch, especially the non-static ones.
- Keep a record of the thought process when you first draw a sketch.

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Figure 14.2 illustrates an example design of hand sketching.

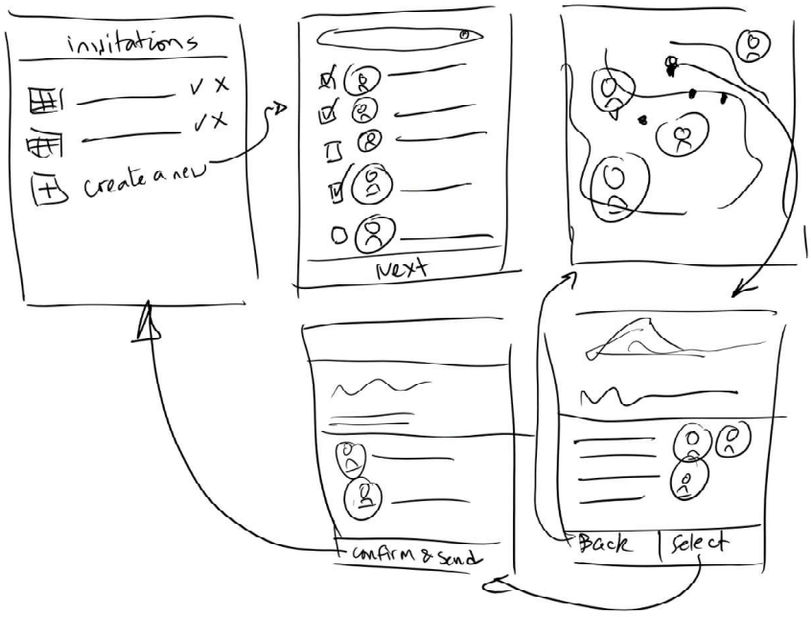

Fig. 14.2 Example of Hand Sketching

14.3.2 Interactive Paper Prototypes

In Human Computer Interaction (HCI), paper prototyping is a widely used method in the user-centred design process, a process that helps developers to create software that meets the user's expectations and needs, especially for designing and testing user interfaces. It is throwaway prototyping and involves creating rough, even hand-sketched, drawings of an interface to use as prototypes, or models, of a design. While paper prototyping seems simple, this method of usability testing can provide useful feedback to aid the design of easier to use products. This is supported by many usability professionals.

Paper prototyping started in the mid-1980s and then became popular in the mid-1990s when companies, such as IBM, Honeywell, Microsoft, and others started using the technique in developing their products. Today, paper prototyping is used widely in user-centred design by usability professionals. More recently, digital paper prototyping has been advocated by companies like Pidoco due to advantages in terms of collaboration, flexibility and cost.

Benefits of Paper Prototyping

Paper prototyping saves time and money since it enables developers to test product interfaces, from software and websites to cell phones and microwave ovens, before they write code or begin development. This also allows for easy and inexpensive modification to existing designs which makes this method useful in the early phases of design. Using paper prototyping allows the entire creative team to be involved

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in the process, which eliminates the chance of someone with key information not being involved in the design process. Another benefit of paper prototyping is that users feel more comfortable being critical of the mock up because it does not have a polished look.

There are different methods of paper prototyping, each of them showing several benefits regarding the communication within the development team and the quality of the product to be developed. In the development team paper prototypes can serve as a visual specification of the Graphical User Interface (GUI), and by this means assure the quality of a software. Prototyping forces a more complete design of the user interface to be captured. In team meetings they provide a communication base between the team members. Testing prototypes at an early stage in development helps to identify software usability problems even before any code is written. The costs and annoyances of later changes are reduced, the support burden is lowered, and the overall quality of the software or website is increased.

Paper prototyping is the quick way to generate the digital ideas by sketching on the paper. Usually, paper prototyping is preferred as the tools to generate the ideas by visually and evaluate in the team and with target customers.

Usage of Paper Prototyping

Paper prototypes should be considered when the following is true:

- When the tools the designer wants to use in creating a prototype are not available.
- When the designer wants to make a sincere effort to allow all members of a team, including those with limited software skills, to take part in the design process.
- When tests of a design lead to a great deal of drawings.
- When the ideas need to be generated fast and evaluated in a short period of time.
- When there is a co-creation workshop need customers and designers to get the ideas together.

Following are the most important areas of application of paper prototypes:

Communication in the Team: One of the major applications of paper prototyping is brainstorming in the development team, to collect and visualize ideas on how an interface might look. The interface is built up step by step, meeting the expectations of all team members. To probe the applicability of the software design, typical use cases are played through and possible pitfalls are identified. The prototype can then be used as a visual specification of the software.

Usability Testing: Paper prototypes can be used for usability testing with real users. In such a test, the user performs realistic tasks by interacting with the paper prototype. The prototype is manipulated by another person reflecting the

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software's reactions to the user input actions. Though seemingly unsophisticated, this method is very successful at discovering usability issues early in the design process.

Three techniques of paper prototyping used for usability testing are comps (short for compositions), wireframes, and storyboards. Comps are visual representations, commonly of websites, that demonstrate various aspects of the interface including fonts, colors, and logos. A wireframe is used to demonstrate the page layout of the interface. Lastly, the storyboards are a series or images that are used to demonstrate how an interface works. These three techniques are useful and can be turned into paper prototypes.

Design Testing: Especially in web design, paper prototypes can be used to probe the illegibility of a design, i.e., a high-fidelity design mockup of a page is printed and presented to a user. Among other relevant issues the user is asked to identify the main navigation, clickable elements, etc. Paper prototyping is also the recommended design testing technique in the contextual design process.

Information Architecture: By applying general and wide paper prototypes, the information architecture of a software or web site can be tested. Users are asked where they would search for certain functionality or settings in software, or topics in a web site. According to the percentage of correct answers, the information architecture can be approved or further refined.

Rapid Prototyping: Paper prototyping is often used as the first step of rapid prototyping. Rapid prototyping involves a group of designers who each create a paper prototype and test it on a single user. After this is done, the designers share their feedback and ideas, at which point, each of them creates a second prototype—this time using presentation software. Functionality is similarly unimportant, but in this case, the aesthetics are closer to the final product. Again each designer's computer prototype is tested on a single user, and the designers meet to share feedback. At this point, actual software prototypes can be created. Usually after these steps have been taken, the actual software is user-friendly the first time around, which saves programming time.

Check Your Progress

1. Explain the term usability.
2. What are the key benefits or importance of usability?
3. Define the Heuristic evaluation method for usability.
4. Why usability tests are done? Define RITE method.
5. Elaborate on the term prototype.
6. What is the importance of hand sketching?
7. Why paper prototyping is used in Human Computer Interaction (HCI)?

14.4 PROGRAMME FACADES

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The Facade pattern, also spelled façade, is a software-design pattern commonly used in Object-Oriented Programming (OOP). Analogous to a facade in architecture, a Facade is an object that serves as a front-facing interface masking more complex underlying or structural code. A facade can,

- Improve the readability and usability of a software library by masking interaction with more complex components behind a single (and often simplified) API (Application Programming Interface).
- Provides a context-specific interface to more generic functionality (complete with context-specific input validation).
- Serves as a launching point for a broader refactor of monolithic or tightly-coupled systems in favour of more loosely-coupled code.

Developers often use the Facade design pattern when a system is very complex or difficult to understand because the system has many interdependent classes or because its source code is unavailable. This pattern hides the complexities of the larger system and provides a simpler interface to the client. It typically involves a single wrapper class that contains a set of members required by the client. These members access the system on behalf of the facade client and hide the implementation details.

The 'Façade' design pattern is one of the twenty-three well-known Gang of Four (GoF) design patterns that describe how to solve recurring design problems to design flexible and reusable object-oriented software, that is, objects that are easier to implement, change, test, and reuse.

Facade design pattern can solve the following problems:

- To make a complex subsystem easier to use, a simple interface should be provided for a set of interfaces in the subsystem.
- The dependencies on a subsystem should be minimized.

Clients that access a complex subsystem directly refer to (depend on) many different objects having different interfaces (tight coupling), which makes the clients hard to implement, change, test and reuse.

Facade design pattern describes the solution as mentioned below.

Define a Facade object that,

- Implements a simple interface in terms of (by delegating to) the interfaces in the subsystem.
- May perform additional functionality before/after forwarding a request.

This enables to work through a Facade object to minimize the dependencies on a subsystem.

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Usage

A Facade is used when an easier or simpler interface to an underlying object is anticipated. Alternatively, an adapter can be used when the wrapper must respect a particular interface and must support polymorphic behaviour. A decorator makes it possible to add or alter behaviour of an interface at run-time.

Pattern	Intent
Adapter	Converts one interface to another so that it matches what the client is expecting.
Decorator	Dynamically adds responsibility to the interface by wrapping the original code.
Facade	Provides a simplified interface.

The Facade pattern is typically used when,

- A simple interface is required to access a complex system.
- A system is very complex or difficult to understand.
- An entry point is needed to each level of layered software.
- The abstractions and implementations of a subsystem are tightly coupled.

Structure of Facade

The structure of Façade can be specified using the following UML (Unified Modeling Language) class and sequence diagram method.

UML Class and Sequence Diagram

In the UML (Unified Modeling Language) class diagram, the Client class does not access the subsystem classes directly. Instead, the Client works through a Facade class that implements a simple interface in terms of (by delegating to) the subsystem classes (Class1, Class2, and Class3). The Client depends only on the simple Facade interface and is independent of the complex subsystem.

The sequence diagram shows the run-time interactions. The Client object works through a Facade object that delegates the request to the Class1, Class2, and Class3 instances that perform the request.

Figure 14.3 (a) and (b) illustrates the sample UML class and sequence diagram for the Facade design pattern.

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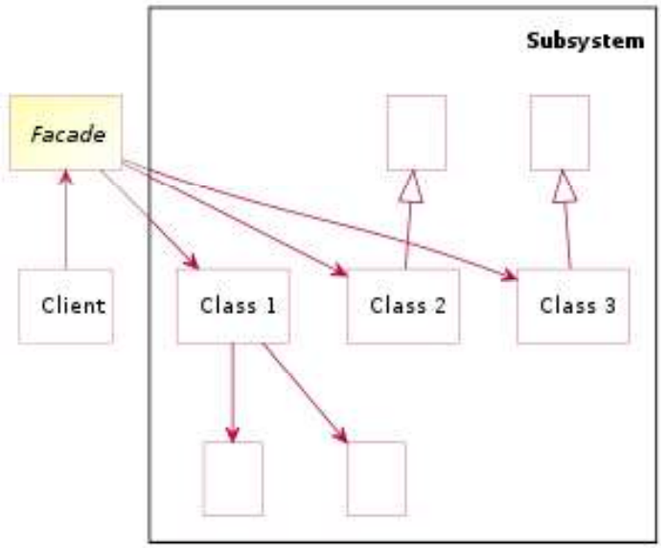
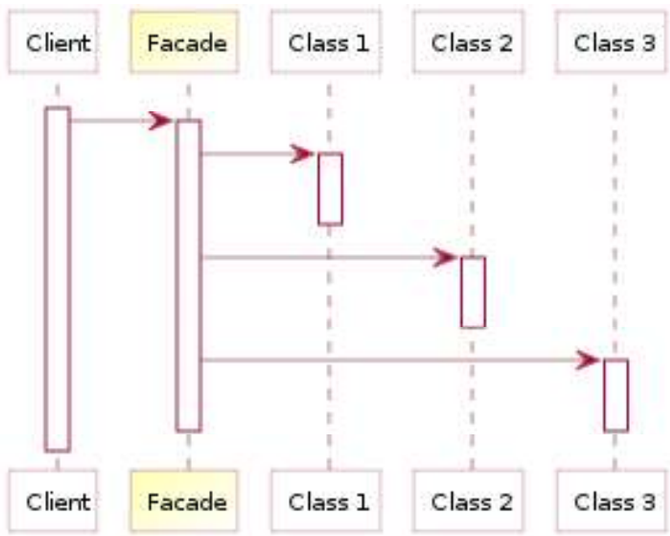


(a) UML Class Diagram



(b) UML Sequence Diagram

Fig. 14.3 *Sample UML Class and Sequence Diagram for the Facade Design Pattern*

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UML Class Diagram

Following Figure 14.4 illustrates the UML class diagram.

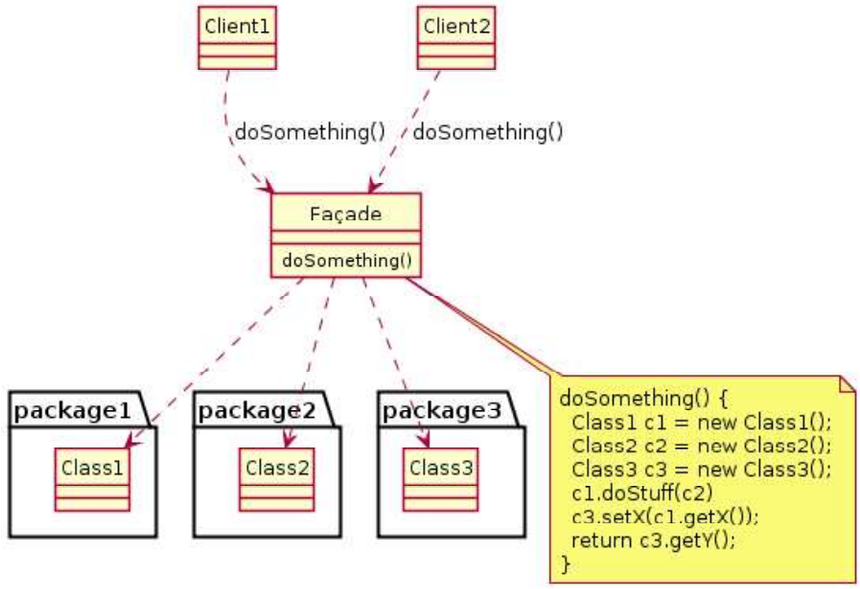

Fig. 14.4 *UML Class Diagram*

Facade

The Facade Class abstracts Packages 1, 2, and 3 from the rest of the application.

Clients

The objects are using the Facade Pattern to access resources from the Packages.

14.5 PROTOTYPE-ORIENTED LANGUAGES

Prototype-based programming is a style of Object-Oriented Programming (OOP) in which behaviour reuse (known as inheritance) is performed via a process of reusing existing objects that serve as prototypes. This model can also be known as prototypal, prototype-oriented, classless, or instance-based programming.

Prototype-based programming uses generalized objects, which can then be cloned and extended. Using fruit as an example, a 'fruit' object would represent the properties and functionality of fruit in general. A 'banana' object would be cloned from the 'fruit' object and general properties specific to bananas would be appended. Each individual 'banana' object would be cloned from the generic 'banana' object. Compare to the class-based paradigm, where a 'fruit' class would be extended by a 'banana' class.

The first Prototype-Oriented Programming (POP) language was 'Self', developed by David Ungar and Randall Smith in the mid-1980s to research topics

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in object-oriented language design. Since the late 1990s, the classless paradigm has grown increasingly popular. Some current prototype-oriented languages are JavaScript and other ECMAScript implementations, such as JScript and Flash's ActionScript 1.0, Lua, Cecil, NewtonScript, Io, Ioke, MOO, REBOL and AHK.

Prototype-based programming is, therefore, a type of Object-Oriented Programming (OOP) in which classes are not explicitly defined, but rather derived by adding properties and methods to an instance of another class or, less frequently, adding them to an empty object. In simple words, this type of programming permits the creation of an object without first defining its class.

Design and Implementation

Prototypal inheritance in JavaScript is described by Douglas Crockford as follows:

> "*You make prototype objects, and then ... make new instances. Objects are mutable in JavaScript, so we can augment the new instances, giving them new fields and methods. These can then act as prototypes for even newer objects. We don't need classes to make lots of similar objects... Objects inherit from objects. What could be more object oriented than that?*"

Supporters of prototype-based programming argue that it encourages the programmer to focus on the behaviour of some set of examples and only later worry about classifying these objects into archetypal objects that are later used in a manner similar to classes. Many prototype-based systems encourage the alteration of prototypes during run-time, whereas only very few class-based object-oriented systems, such as the dynamic object-oriented system, Common Lisp, Dylan, Objective-C, Perl, Python, Ruby or Smalltalk allow classes to be altered during the execution of a program.

Almost all prototype-based systems are based on interpreted and dynamically typed languages. Systems based on statically typed languages are technically feasible, however. The 'Omega' language discussed in 'Prototype-Based Programming' is an example of such a system, though according to Omega's website even Omega is not exclusively static, but rather its "Compiler may choose to use static binding where this is possible and may improve the efficiency of a program".

Object Construction

In prototype-based languages there are no explicit classes. Objects inherit directly from other objects through a prototype property. The prototype property is called '`prototype`' in 'Self' and 'JavaScript', or '`proto`' in 'Io'. There are two methods of constructing new objects, namely ex nihilo, 'from nothing', object creation or through cloning an existing object. The former is supported through some form of object literal, declarations where objects can be defined at runtime through special syntax, such as {…...} and passed directly to a variable. While most systems support a variety of cloning, ex nihilo object creation is not as prominent.

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In class-based languages, a new instance is constructed through a class's constructor function, a special function that reserves a block of memory for the object's members (properties and methods) and returns a reference to that block. An optional set of constructor arguments can be passed to the function and are usually held in properties. The resulting instance will inherit all the methods and properties that were defined in the class, which acts as a kind of template from which similarly typed objects can be constructed.

Systems that support ex nihilo object creation allow new objects to be created from scratch without cloning from an existing prototype. Such systems provide a special syntax for specifying the properties and behaviours of new objects without referencing existing objects. In many prototype languages there exists a root object, often called 'Object', which is set as the default prototype for all other objects created in run-time and which carries commonly needed methods, such as a `toString()` function to return a description of the object as a string. One useful aspect of ex nihilo object creation is to ensure that a new object's slot (properties and methods) names do not have namespace conflicts with the top-level Object `object`. In the JavaScript language, one can do this by using a null prototype, i.e., `Object.create(null)`.

Cloning refers to a process whereby a new object is constructed by copying the behaviour of an existing object (its prototype). The new object then carries all the qualities of the original. The new object can be modified. In some systems the resulting child object maintains an explicit link (via delegation or resemblance) to its prototype, and changes in the prototype cause corresponding changes to be apparent in its clone.

Check Your Progress

8. Explain the term program Façade.
9. Which design pattern problems can be solved using Façade?
10. When a Facade pattern is typically used?
11. Define the term prototype-based programming.
12. How the generalized objects are cloned and extended in prototype-based programming?
13. How object construction is done in prototype-based programming?

14.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience. In software engineering, usability is the degree to

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which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use. Usability includes methods of measuring usability, such as needs analysis and the study of the principles behind an object's perceived efficiency. In Human Computer Interaction (HCI) and computer science, usability studies the elegance and clarity with which the interaction with a computer program or a web site or web usability is designed. Usability considers user satisfaction and utility as quality components, and aims to improve user experience through iterative design.

2. Following are the key benefits or importance of usability:
   - Higher Revenues through Increased Sales
   - Increased User Efficiency and User Satisfaction
   - Reduced Development Costs
   - Reduced Support Costs

   An increase in usability generally positively affects several facets of a company's output quality. In particular, the benefits or importance has the following common areas:
   - Increased Productivity
   - Decreased Training and Support Costs
   - Increased Sales and Revenues
   - Reduced Development Time and Costs
   - Reduced Maintenance Costs
   - Increased Customer Satisfaction
3. Heuristic evaluation is a usability engineering method for finding and assessing usability problems in a user interface design as part of an iterative design process. It involves having a small set of evaluators examining the interface and using recognized usability principles, the 'Heuristics'. It is the most popular of the usability inspection methods, as it is quick, cheap, and easy. Heuristic evaluation was developed to aid in the design of computer user interface design. It relies on expert reviewers to discover usability problems and then categorise and rate them by a set of principles, heuristics.
4. Regardless to how carefully a system is designed, all theories must be tested using usability tests. Usability tests involve typical users using the system (or product) in a realistic environment. Observation of the user's behaviour, emotions, and difficulties while performing different tasks, often identify areas of improvement for the system.

   Rapid Iterative Testing and Evaluation (RITE) is an iterative usability method similar to traditional usability testing. The tester and team must define a target population for testing, schedule participants to come into the lab,

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decide on how the user's behaviours will be measured, construct a test script and have participants engage in a verbal protocol.

5. A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming. A prototype is generally used to evaluate a new design to enhance precision by system analysts and users. Prototyping serves to provide specifications for a real, working system rather than a theoretical one. Fundamentally, a prototype is a draft version of a product that allows the user to explore the ideas and show the intention behind a feature or the overall design concept to users before investing time and money into development. A prototype can be anything from paper drawings (low-fidelity) to something that allows click-through of a few pieces of content to a fully functioning site (high-fidelity).
6. Sketching is a distinctive and typical form of drawing which are used by the designers in order to propose, explore, refine and communicate the basic concept and ideas. Typically, the sketching is one of the earliest forms of prototyping that can be used. It requires very little effort and does not necessarily rely on artistic levels of drawing skill to prove useful, and therein lies its value. Hand sketches can be used to illustrate the concept and ideas for introducing them into the real world, even the simplest and crudest of sketches can easily achieve that. Hand sketching is the effective way for conveying the design specifications in a timely and cost-efficient manner.
7. In Human Computer Interaction (HCI), paper prototyping is a widely used method in the user-centred design process, a process that helps developers to create software that meets the user's expectations and needs, especially for designing and testing user interfaces. It is throwaway prototyping and involves creating rough, even hand-sketched, drawings of an interface to use as prototypes, or models, of a design. While paper prototyping seems simple, this method of usability testing can provide useful feedback to aid the design of easier to use products. This is supported by many usability professionals.
8. The Facade pattern, also spelled façade, is a software-design pattern commonly used in Object-Oriented Programming (OOP). Analogous to a facade in architecture, a Facade is an object that serves as a front-facing interface masking more complex underlying or structural code. A facade can,
   - Improve the readability and usability of a software library by masking interaction with more complex components behind a single (and often simplified) API (Application Programming Interface).

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- Provides a context-specific interface to more generic functionality (complete with context-specific input validation).
- Serves as a launching point for a broader refactor of monolithic or tightly-coupled systems in favour of more loosely-coupled code.

9. Facade design pattern can solve the following problems:
   - To make a complex subsystem easier to use, a simple interface should be provided for a set of interfaces in the subsystem.
   - The dependencies on a subsystem should be minimized.

   Clients that access a complex subsystem directly refer to (depend on) many different objects having different interfaces (tight coupling), which makes the clients hard to implement, change, test and reuse.
10. The Facade pattern is typically used when,
    - A simple interface is required to access a complex system.
    - A system is very complex or difficult to understand.
    - An entry point is needed to each level of layered software.
    - The abstractions and implementations of a subsystem are tightly coupled.
11. Prototype-based programming is a style of Object-Oriented Programming (OOP) in which behaviour reuse (known as inheritance) is performed via a process of reusing existing objects that serve as prototypes. This model can also be known as prototypal, prototype-oriented, classless, or instance-based programming.
12. Prototype-based programming uses generalized objects, which can then be cloned and extended. Using fruit as an example, a 'fruit' object would represent the properties and functionality of fruit in general. A 'banana' object would be cloned from the 'fruit' object and general properties specific to bananas would be appended. Each individual 'banana' object would be cloned from the generic 'banana' object. Compare to the class-based paradigm, where a 'fruit' class would be extended by a 'banana' class.
13. In prototype-based languages there are no explicit classes. Objects inherit directly from other objects through a prototype property. The prototype property is called 'prototype' in 'Self' and 'JavaScript', or 'proto' in 'Io'. There are two methods of constructing new objects, namely ex nihilo, 'from nothing', object creation or through cloning an existing object. The former is supported through some form of object literal, declarations where objects can be defined at runtime through special syntax, such as {…...} and passed directly to a variable. While most systems support a variety of cloning, ex nihilo object creation is not as prominent.

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14.7 SUMMARY

- Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience.
- In software engineering, usability is the degree to which a software can be used by specified consumers to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a quantified context of use.
- A usability study may be conducted as a primary job function by a usability analyst or as a secondary job function by designers, technical writers, marketing personnel, and others.
- Usability includes methods of measuring usability, such as needs analysis and the study of the principles behind an object's perceived efficiency.
- In Human Computer Interaction (HCI) and computer science, usability studies the elegance and clarity with which the interaction with a computer program or a web site or web usability is designed.
- Usability considers user satisfaction and utility as quality components, and aims to improve user experience through iterative design.
- Usability describes the quality of user experience across websites, software, products, and environments. Usability is also important in website development (web usability).
- According to Jakob Nielsen, "Studies of user behaviour on the Web find a low tolerance for difficult designs or slow sites. People do not want to wait and they do not want to learn how to use a home page. There is no such thing as a training class or a manual for a Web site. People have to be able to grasp the functioning of the site immediately after scanning the home page—for a few seconds at most".
- Usability can also include the concept of prototypicality, which is how much a particular thing conforms to the expected shared norm, for instance, in website design, users prefer sites that conform to recognised design norms.
- International Organization for Standardization (ISO) defines usability as, "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use".
- Usability Testing (UT) is the measurement of ease of use of a product or piece of software.
- In contrast, Usability Engineering (UE) is the research and design process that ensures a product with good usability. Usability is a non-functional requirement.

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- As with other non-functional requirements, usability cannot be directly measured but must be quantified by means of indirect measures or attributes, such as the number of reported problems with ease-of-use of a system.
- ISO/TR 16982:2002 "Ergonomics of Human System Interaction (HIS)—Usability methods supporting human centred design" is an International Standards Organization (ISO) standard that provides information on human centred usability methods that can be used for design and evaluation. It details the advantages, disadvantages, and other factors relevant to using each usability method.
- ISO 9241 is a multi-part standard that covers a number of aspects of people working with computers. Although originally titled Ergonomic requirements for office work with Visual Display Terminals (VDTs), it has been retitled to the more generic Ergonomics of Human System Interaction.
- IEC 62366-1:2015 + COR1:2016 & IEC/TR 62366-2 provide guidance on usability engineering specific to a medical device.
- The design team should be user-driven and it should be in direct contact with potential users. Several evaluation methods, including personas, cognitive modeling, inspection, inquiry, prototyping, and testing methods may contribute to understanding potential users and their perceptions of how well the product or process works.
- Iterative design is a design methodology based on a cyclic process of prototyping, testing, analysing, and refining a product or process. Based on the results of testing the most recent iteration of a design, changes and refinements are made. This process is intended to ultimately improve the quality and functionality of a design.
- In iterative design, interaction with the designed system is used as a form of research for informing and evolving a project, as successive versions, or iterations of a design are implemented.
- There are usability evaluation methods for all stages of design and development, from product definition to final design modifications. When choosing a method, consider cost, time constraints, and appropriateness.
- Cognitive modeling involves creating a computational model to estimate how long it takes people to perform a given task. Models are based on psychological principles and experimental studies to determine times for cognitive processing and motor movements.
- Cognitive models can be used to improve user interfaces or predict problem errors and pitfalls during the design process.
- GOMS stands for Goals, Operator, Methods, and Selection Rules. It is a family of techniques that analyses the user complexity of interactive systems.

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- Goals are what the user must accomplish. An operator is an action performed in pursuit of a goal. A method is a sequence of operators that accomplish a goal. Selection rules specify which method satisfies a given goal, based on context.
- Inspection usability evaluation methods involve observation of users by an experimenter, or the testing and evaluation of a program by an expert reviewer.
- Heuristic evaluation is a usability engineering method for finding and assessing usability problems in a user interface design as part of an iterative design process. It involves having a small set of evaluators examining the interface and using recognized usability principles, the 'Heuristics'. It is the most popular of the usability inspection methods, as it is quick, cheap, and easy.
- Heuristic evaluation was developed to aid in the design of computer user interface design.
- Usability inspection is a review of a system based on a set of guidelines. The review is conducted by a group of experts who are deeply familiar with the concepts of usability in design.
- Rapid prototyping is a method used in early stages of development to validate and refine the usability of a system. It can be used to quickly and cheaply evaluate user-interface designs without the need for an expensive working model.
- These usability evaluation methods involve testing of subjects for the most quantitative data. Usually recorded on video, they provide task completion time and allow for observation of attitude.
- Usability tests involve typical users using the system (or product) in a realistic environment. Observation of the user's behaviour, emotions, and difficulties while performing different tasks, often identify areas of improvement for the system.
- Remote usability testing, also known as unmoderated or asynchronous usability testing, involves the use of a specially modified online survey, allowing the quantification of user testing studies by providing the ability to generate large sample sizes, or a deep qualitative analysis without the need for dedicated facilities.
- The 'Think Aloud' protocol is a method of gathering data that is used in both usability and psychology studies. It involves getting a user to verbalize their thought processes, i.e., expressing their opinions, thoughts, anticipations, and actions, as they perform a task or set of tasks.

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- Rapid Iterative Testing and Evaluation (RITE) is an iterative usability method similar to traditional usability testing. The tester and team must define a target population for testing, schedule participants to come into the lab, decide on how the user's behaviours will be measured, construct a test script and have participants engage in a verbal protocol.
- Component-based usability testing is an approach which aims to test the usability of elementary units of an interaction system, referred to as interaction components. The approach includes component-specific quantitative measures based on user interaction recorded in log files, and component-based usability questionnaires.
- Benchmarking creates standardized test materials for a specific type of design. Once there is a benchmark, other designs can be compared to it to determine the usability of the system.
- A prototype is an early sample, model, or release of a product built to test a concept or process. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming.
- A prototype is generally used to evaluate a new design to enhance precision by system analysts and users.
- Prototyping serves to provide specifications for a real, working system rather than a theoretical one. In some design workflow models, creating a prototype is the step between the formalization and the evaluation of a concept or notion.
- A prototype is a useful in identifying objects, behaviours and concepts which are considered the accepted norm and is analogous with terms, such as stereotypes and archetypes.
- The word prototype derives from the Greek word 'Prototypon' which means 'Primitive Form', neutral of 'Prototypos', 'Original, Primitive', from 'Protos', 'First' and 'Typos', 'Impression'.
- Fundamentally, a prototype is a draft version of a product that allows the user to explore the ideas and show the intention behind a feature or the overall design concept to users before investing time and money into development.
- A prototype can be anything from paper drawings (low-fidelity) to something that allows click-through of a few pieces of content to a fully functioning site (high-fidelity).
- Software prototyping is the activity of creating prototypes of software applications, i.e., incomplete versions of the software program being

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developed. It is an activity that can occur in software development and is comparable to prototyping as known from other fields, such as mechanical engineering or manufacturing.

- The benefit or importance of prototype is that it is less expensive to change a product early in the development process than to make change once the site is developed. Therefore, the software developer/designer should consider building prototypes early in the process.
- Prototyping permits the software developer/designer to gather feedback from users while they are still planning and designing the specific Web site.
- Low-fidelity prototypes are often paper-based and do not allow user interactions. They range from a series of hand-drawn mock-ups to printouts. In theory, low-fidelity sketches are quicker to create.
- High-fidelity prototypes are computer-based, and usually allow realistic (mouse-keyboard) user interactions. High-fidelity prototypes take software developer/designer as close as possible to a true representation of the user interface.
- Sketching is one of the earliest forms of prototyping that can be used. It requires very little effort and does not necessarily rely on artistic levels of drawing skill to prove useful, and therein lies its value.
- Hand sketches can be used to illustrate the concept and ideas for introducing them into the real world, even the simplest and crudest of sketches can easily achieve that.
- Hand sketching is the effective way for conveying the design specifications in a timely and cost-efficient manner.
- Sketching is a distinctive and typical form of drawing which are used by the designers in order to propose, explore, refine and communicate the basic concept and ideas.
- In Human Computer Interaction (HCI), paper prototyping is a widely used method in the user-centred design process, a process that helps developers to create software that meets the user's expectations and needs, especially for designing and testing user interfaces.
- Paper prototyping is throwaway prototyping and involves creating rough, even hand-sketched, drawings of an interface to use as prototypes, or models, of a design.
- Paper prototyping saves time and money since it enables developers to test product interfaces, from software and websites to cell phones and microwave ovens, before they write code or begin development.

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- Paper prototyping is the quick way to generate the digital ideas by sketching on the paper. Usually, paper prototyping is preferred as the tools to generate the ideas by visually and evaluate in the team and with target customers.
- Paper prototypes can be used for usability testing with real users. In such a test, the user performs realistic tasks by interacting with the paper prototype. The prototype is manipulated by another person reflecting the software's reactions to the user input actions.
- The Facade pattern, also spelled façade, is a software-design pattern commonly used in Object-Oriented Programming (OOP). Analogous to a facade in architecture, a Facade is an object that serves as a front-facing interface masking more complex underlying or structural code.
- The 'Façade' design pattern is one of the twenty-three well-known Gang of Four (GoF) design patterns that describe how to solve recurring design problems to design flexible and reusable object-oriented software, that is, objects that are easier to implement, change, test, and reuse.
- The structure of Façade can be specified using the UML (Unified Modeling Language) class and sequence diagram method.
- Prototype-based programming is a style of Object-Oriented Programming (OOP) in which behaviour reuse (known as inheritance) is performed via a process of reusing existing objects that serve as prototypes. This model can also be known as prototypal, prototype-oriented, classless, or instance-based programming.
- Prototype-based programming uses generalized objects, which can then be cloned and extended.
- Prototype-based programming is, therefore, a type of Object-Oriented Programming (OOP) in which classes are not explicitly defined, but rather derived by adding properties and methods to an instance of another class or, less frequently, adding them to an empty object.
- Cloning refers to a process whereby a new object is constructed by copying the behaviour of an existing object (its prototype). The new object then carries all the qualities of the original. The new object can be modified.

14.8 KEY WORDS

- **Usability:** Usability can be described as the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience.
- **Usability as per ISO:** The International Organization for Standardization (ISO) defines usability as, "The extent to which a product can be used by

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specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use".

- **Usability Testing (UT):** Usability Testing (UT) is the measurement of ease of use of a product or piece of software.
- **Usability Engineering (UE):** Usability Engineering (UE) is the research and design process that ensures a product with good usability.
- **Iterative design:** Iterative design is a design methodology based on a cyclic process of prototyping, testing, analysing, and refining a product or process. Based on the results of testing the most recent iteration of a design, changes and refinements are made.
- **Inspection methods:** The inspection usability evaluation methods involve observation of users by an experimenter, or the testing and evaluation of a program by an expert reviewer.
- **Heuristic evaluation:** Heuristic evaluation is a usability engineering method for finding and assessing usability problems in a user interface design, it involves having a small set of evaluators examining the interface and using recognized usability principles, the 'Heuristics'.
- **Usability inspection:** Usability inspection is a review of a system based on a set of guidelines. The review is conducted by a group of experts who are deeply familiar with the concepts of usability in design.
- **Component-based usability testing:** Component-based usability testing is an approach which aims to test the usability of elementary units of an interaction system, referred to as interaction components, the approach includes component-specific quantitative measures based on user interaction recorded in log files, and component-based usability questionnaires.
- **Benchmarking:** Benchmarking creates standardized test materials for a specific type of design. Once there is a benchmark, other designs can be compared to it to determine the usability of the system.
- **Prototype:** A prototype is an early sample, model or release of a product built to test a concept or process, a prototype is generally used to evaluate a new design to enhance precision by system analysts and users.

14.9 SELF-ASSESSMENT QUESTIONS AND EXERCISES

Short-Answer Questions

1. Define the term usability.
2. Give the ISO definition of usability.

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3. What is prototypes usability?
4. State the purpose of usability.
5. Explain the importance of usability.
6. Why is usability testing done?
7. Explain the importance of prototypes.
8. Why hand sketching is used?
9. Define interactive paper prototypes.
10. Elaborate on programme façade.
11. Explain the term prototype-oriented languages.

Long-Answer Questions

1. Briefly discuss the significant and characteristic features of usability giving relevant examples.
2. "Usability considers user satisfaction and utility as quality components, and aims to improve user experience through iterative design." Justify the statement with the help of examples.
3. Explain the term usability as per ISO and according to Jakob Nielsen.
4. What is intuitive interface? Explain giving examples.
5. Elaborate on the purpose, key benefits or importance of usability.
6. Discuss in detail how the designing for usability is accomplished.
7. Briefly explain the various usability evaluation methods giving examples.
8. Explain the different types of usability testing methods with the help of relevant examples.
9. Discuss the significance of prototypes in software programming.
10. Explain the types and advantages of prototypes usability.
11. Elaborate on the importance of hand sketching and interactive paper prototypes giving relevant examples.
12. Discuss in details the features, usage, structure and objects of programme façade giving examples.
13. Briefly discuss about the prototype-oriented languages giving examples.

14.10 FURTHER READINGS

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