UNIT 1 INTRODUCTION TO COMPUTER GRAPHICS

Structures **Page Nos.**

1.0 INTRODUCTION

Early man used drawings to communicate even before he learnt to talk, write, or count. Incidentally, these ancient hieroglyphics (picture-writings) communicate as well today, as they must have done thousands of years ago, this fully supports the saying that "A picture is worth a thousand words" and in the era of computers we can add on to it or we may as well revise the saying to "*A computer is worth a million pictures!" ;* so, you can estimate the power of a computer as a communication system.

Now, with the advances in computer hardware and software, graphics has come a full circle and, more and more people are teaching and learning, communicating and sharing their ideas through the medium of graphics. By **graphics**, we mean any sketch, drawing, special artwork or other material that pictorially depict an object or a process or otherwise conveys information, as a supplement to or instead of written descriptions, and the utilisation of computers to accomplish such tasks leads to a new discipline of computer graphics. Traditionally, graphics has referred to engineering drawings of buildings, bridges, machine parts etc. and scientific drawings such as x-y curves, network and process flowcharts. In recent decades, graphics has ventured into industrial design, advertising and other artistic endeavours. During the last few years, even newspapers and periodicals aimed at the common man have begun to utilise graphics to present quantitative news such as selection results and production statistics. Computer graphics can do all this and more. In fact, the power and easy availability of computer graphics have increased the use of pictures to replace and augment words to describe, educate, or inform a wide variety of audiences, on a wide variety of subjects.

In this unit, we shall concentrate on the graphic capabilities and potential of the digital computer plus we will discuss the meaning of the term graphics and its types, in addition to which, we will also discuss the hardware used for practical application of graphics in different streams of life. The software section however, will be discussed in Block 4 of this course.

1.1 OBJECTIVES

After completing this unit, you should be able to:

- describe computer graphics, its features and characteristics;
- discuss applications of computer graphics in various fields, and
- describe various types of hardware, required to work with graphic systems.

1.2 WHAT IS COMPUTER GRAPHICS?

The meaning of the term Graphics, is Graphical Tricks. Every image or picture is in fact a graph and when different mathematical tricks are used to manipulate some change in its properties like shape, size, motion etc., through the help of computers then, the representation is nothing but computer graphics, so we can say that "*Computer Graphics (CG) is the field of visual computing, where one utilises computers both to generate visual images synthetically and to integrate or alter visual and spatial information sampled from the real world*." **Or** "*Computer Graphics is the pictorial representation manipulation of data by a computer*" **Or** "*Computer Graphics refers to any sketch, drawing, special artwork or other material generated with the help of computer to pictorially depict an object or a process or otherwise convey information, as a supplement to or instead of written descriptions*". Computer Graphics is a complex and diversified field. A Picture is a fundamental cohesive concept in Computer Graphics. Each picture consists of points called pixels (Picture- element). If we consider a complex picture, then complex database for pixels are considered, hence, complex algorithm are required to access them. These complex database contain data organised in various data structures such as ring structures,
B-tree etc.

In our earlier courses CS-60, we had learned mathematical tricks to do jugglery with the graphs that resulted from different functions, now let us learn how to juggle with graphics by using computers. There are many algorithms, which can be materialised to produce graphical effects on the screen through several graphical tools based on different languages that are available in the market.

Computer graphics can be broadly divided into the following classes:

- Business Graphics or the broader category of Presentation Graphics, which refers to graphics, such as bar-charts (also called histograms), pie-charts, pictograms (i.e., scaled symbols), x-y charts, etc. used to present quantitative information to inform and convince the audience.
- Scientific Graphics, such as x-y plots, curve-fitting, contour plots, system or program flowcharts etc.
- Scaled Drawings, such as architectural representations, drawings of buildings, bridges, and machines.
- Cartoons and artwork, including advertisements.
- Graphics User Interfaces (GUIs) which are the images that appear on almost all computer screens these days, designed to help the user utilise the software without having to refer to manuals or read a lot of text on the monitor.

We will discuss the various classes of computer graphics mentioned above in the following sections of this unit.

The most familiar and useful class of computer graphics involves movies and video games. Movies generally need graphics that are indistinguishable from physical reality, whereas video games need graphics that can be generated quickly enough to be perceived as smooth motion. These two needs are incompatible, but they define two-ways of communications between users and computations. In video games, the subject matter of computations is generally characters chasing and shooting at each other. A more familiar use of computer graphics exists for interacting with scientific computations apart from movies and games. This familiarisation of the use of computer graphics has influenced our life, through simulations, virtual reality, animation, we can extend the scope of education, entertainment, analysis etc. So, in global terms Computer graphics can be categorised in two ways:

Interactive Computer Graphics which is interactively used by users e.g., games. We will discuss details about this type of graphic systems in Block 4.

Passive Computer Graphic which has no option for users to interact or use computer graphics e.g., movies. We will discuss details about this type of graphic systems in Block 4.

1.3 APPLICATIONS

Research in computer graphics covers a broad range of application including both photorealistic and non-photorealistic image synthesis, image-based modeling and rendering and other multi-resolution methods, curve and surface design, range scanning, surface reconstruction and modeling, motion capture, motion editing, physics-based modeling, animation, interactive 3D user interfaces, image editing and colour reproduction. Work is going on in various fields but computer vision is a hot topic, where research tackles the general problem of estimating properties of an object or scene through the processing of images, both 2D photographs and 3D range maps. Within this broad scope, we investigate efficient ways to model, capture, manipulate, retrieve, and visualise real-world objects and environments.

Once you get into computer graphics, you’ll hear about all kinds of applications that do all kinds of things. This section will discuss not only the applications but also the software suitable for that type of application, so it is necessary to give you an understanding of what various applications do. While working on a project, you may need images, brochures, a newsletter, a PowerPoint presentation, poster, DVD etc. Thus, the question arises what software do I need to get my job done. The section will help to straighten all of that out in your head. Hopefully, if you know what does what, you won’t waist money duplicating purchases, and when other designers or co-workers are talking shop, you’ll know what is going on.

Graphic design applications are basically broken down on the basis of a few considerations. The first two considerations are, “Is your project for print, or web”. When I say web, what I really mean is monitor based publishing. This means that you are going to see your work on a computer screen, and television, or a big screen projector. So, as you read through this section, whenever we say “web based”, we mean monitor based. Beyond print and web, here are the various categories that we can think of that various applications would fit into; Image Manipulation; Vector Graphics; Page Layout; Web sight development; Presentation Software; Video Editing; DVD Production; Animation and Interactivity etc. If you are creating, or learning to create graphic design, computer art, or maybe “Digital Media” is the term that we should use, then it’s a good thing to understand the function of each application. There are many applications in the market and most of them are expensive. A few of the various application areas that are influenced by Computer graphics are:

- Presentation Graphics
- Painting and Drawing
- Photo Editing
- Scientific Visualisation
- Image Processing

- Education, Training, Entertainment and CAD
- Simulations
- Animation and Games

Let us discuss these fields one by one.

1.3.1 Presentation Graphics

The moment you are going to represent yourself or your company or product or research paper etc. simply standing and speaking is quite ineffective. Now, in such a situation where no one stands with you, your ultimate companions are the slides which have some information either in the form of text, charts, graphs etc., which make your presentation effective. If you think more deeply, these are nothing but the ways some curves (text/graph/charts) which are used in some sequence and to create such things, graphics is the ultimate option, this application of graphics is known as presentation graphics, which can be done very effectively through computers now-a-days. There are some softwares which helps you present you and your concerned effectively. Such application softwares are known as **Presentation Graphics softwares – which is a software that shows information in the form of a slide show** (A slideshow is a display of a series of chosen images, which is done for artistic or instructional purposes. Slideshows are conducted by a presenter using an apparatus which could be a computer or a projector).

Three major functions of presentation graphics are:

- an editor that allows text to be inserted and formatted,
- a method for inserting and manipulating graphic images, and
- a slide-show system to display the content.

The program that helps users to create presentations such as visual aids, handouts, and overhead slides to process artwork, graphics, and text and produce a series of 'slides'– which help speakers get their message across are presenation graphics softwares.

Example programs include some softwares like Apple's Keynote, Openoffice's (Star Office-by Sun microsystems) Impress, Microsoft Powerpoint and (for multimedia presentations, incorporating moving pictures, and sounds) Macromedia Director. Custom graphics can also be created in other programs such as Adobe Photoshop or Adobe Illustrator and then imported. With the growth of video and digital photography, many programs that handle these types of media also include presentation functions for displaying them in a similar "slide show" format.

Similar to programming extensions for an Operating system or web browser, "add ons" or plugins for presentation programs can be used to enhance their capabilities. For example, it would be useful to export a PowerPoint presentation as a Flash animation or PDF document. This would make delivery through removable media or sharing over the Internet easier. Since PDF files are designed to be shared regardless of platform and most web browsers already have the plugin to view Flash files, these formats would allow presentations to be more widely accessible.

We may say that Presentation graphics is more than just power point presentation because it includes any type of slide presentation, bar chart, pie chart, graphs and multimedia presentation. The key advantage of this software is that it help you show abstracts of representation of work.

Note: There are some softwares like canvas that improves the presentation created through powerpoint or keynote software. Although these software packages contain a lot of handy features, they lack many vector and image creation capabilities, therefore, creating a need for a graphic/illustration program. Scientists, engineers, and other technically-oriented professionals often call upon Canvas and its host of vector, image editing, and text features to create the exciting visual components for their presentation projects.

General questions that strike many graphic designers, students, and engineers rushing to import their illustrations and images into presentations are:

- What resolution should be used?
- Which file format is best?
- How do I keep the file size down?

Let us discuss in brief the suitability of the technique (Vector or Bitmap), and the file format appropriate to the creation of a better presentation.

Resolution

Graphic illustrations are used in presentations to help convey an idea or express a mood, two kinds of illustration graphics are:

1) Vector, and
2) Bitmap.

You may wonder which one of these is a better format when exporting to some software PowerPoint or Keynote or impress. The truth is that there are different situations that call for different methods, but here are some things to look out for. For instance, vectors are objects that are defined by anchor points and paths, while bitmapped graphics are digital images composed of pixels. **The advantage** of using vector graphics is that they are size independent, meaning that they could be resized with no loss in quality. Bitmapped graphics, on the other hand, provide a richer depth of colour but are size dependent and appear at the stated 72 dpi size**.**

File format

Say, we want an image of a Fly. The wings are partially transparent and to represent that in our presentation what be problematic if proper file format is not there. This choice of file format is hidden in the software that you may be using. Two cases for the same situation are discussed below:

- **The right file format that will allow us to create a transparent background in Keynote presentation.** Even though Keynote could import all common file formats such as GIF, JPG, and BMP, there is one format that will work particularly well which is .PSD. Using .PSD (Photoshop format) we are able to easily place a transparent image, even partially transparent sections of the image, such as the wings of the fly, as well as retain their properties.

- **The right file format that will allow us to create a transparent background in PowerPoint.** Even though PowerPoint could import all common file formats such as GIF, JPG, and BMP, there are two particular file formats that will work exceptionally well: TIFF and PNG. Using TIFF (Tagged-Image File Format) or PNG (Portable Network Graphic), we could easily remove the unwanted background quickly and easily in PowerPoint, a feature not available to the other mentioned file formats.

Note: TIFF or PNG: TIFF has been around longer than PNG, which was originally designed to replace GIF on the Web. PowerPoint works well with both these files when creating transparent backgrounds but generally PNG creates smaller file sizes with no loss of quality.

1.3.2 Painting and Drawing

When we talk about graphics, we mean pictures, and pictures can be either illustrations or photographs. If you want to get graphics into a Web page or multimedia presentation, you either have to create them in some kind of graphics application by drawing or painting them right there in the application, or bringing them into the application via a digital camera or scanner, and then editing and saving them in a form suitable to your medium.

Many software applications offer a variety of features for creating and editing pictures on the computer. Even multimedia authoring and word processing programs include some simple features for drawing on the computer.

So, painting and drawing application in computer graphics allows the user to pick and edit any object at any time. The basic difference is as follows:

Drawing in a software application means using tools that create "objects," such as squares, circles, lines or text, which the program treats as discrete units. If you draw a square in PowerPoint, for example, you can click anywhere on the square and move it around or resize it. It's an object, just like typing the letter "e" in a word processor. i.e., a drawing program allows a user to position standard shape (also called symbols, templates, or objects) which can be edited by translation, rotations and scaling operations on these shapes.

Painting functions, on the other hand, don't create objects. If you look at a computer screen, you'll see that it's made up of millions of tiny dots called pixels. You'll see the same thing in a simpler form if you look at the colour comics in the Sunday newspaper — lots of dots of different colour ink that form a picture. Unlike a drawing function, a paint function changes the colour of individual pixels based on the tools you choose. In a photograph of a person's face, for example, the colours change gradually because of light, shadow and complexion. You need a paint function to create this kind of effect; there's no object that you can select or move the way you can with the drawn square i.e., a painting program allows the user to paint arbitrary swaths using brushes of various sizes, shapes, colour and pattern. More painting program allows placement of such predefined shapes as rectangles, polygon and canvas. Any part of the canvas can be edited at pixel level.

The reason why the differences are important is that, as noted earlier, many different kinds of programs offer different kinds of graphics features at different levels of sophistication, but they tend to specialise in one or the other. For example:

1) Many word processors, like Word, offer a handful of simple drawing functions. They aren't that powerful, but if all you need is a basic illustration made up of simple shapes to clarify a point, they're fine.

2) Some programs specialise in graphics creation. Of these, some are all-purpose programs, like KidPix, which offers both drawing and painting functions. KidPix is targeted specifically at children; it has a simplified interface and lacks the sophisticated functions a professional artist might want.

   Other programs, like Adobe PhotoShop, specialise in painting functions, even though they may include drawing functions as well. Painter is a paint-oriented program that offers highly sophisticated, "natural media" functions that approximate the effects of watercolours or drawing with charcoal on textured paper.

   Other graphics programs, such as Adobe Illustrator, specialise in drawing for professional artists and designers; AutoCAD is used mainly for technical and engineering drawing.

3) Page layout, presentation, multimedia authoring and Web development programs usually contain a variety of graphics functions ranging from the simple to the

complex, but their main purpose is composition, not image creation or editing. That is, they allow you to create or import text and graphics and, perhaps, sound, animation and video.

Most of the graphics features in these types of programs are limited to drawing functions because they assume that you will do more complex work in a program dedicated to other functions (e.g., writing in a word processor, editing photos in a paint program), then import your work to arrange the different pieces in the composition program. (Some multimedia authoring systems, however, also offer painting and drawing functions.)

By the way, the differences in composition programs are mainly in the form of their output: Page layout programs, such as PageMaker and QuarkXPress, are for composing printed pages; presentation and multimedia authoring programs, such as PowerPoint and HyperStudio, are for slide shows and computer displays; and Web development applications, like Netscape Composer, are for, well, Web pages.

4) What if you are going to make a magazine, newspaper, book or maybe a multipage menu for a restaurant. In that case, we need a page layout program. The well known softwares in page layout are:

a) Quark Express
b) Page Maker (Adobe)
c) Indesign (Adobe)
d) Publisher (Microsoft)

The Queen of Page Layout is Quark Express, owned by Quark Express and Indesign is the King owned by Adobe and finally there is Microsoft Publisher, which is very easy to use.

5) To Create posters, brochures, business cards, stationary, coffee mug design, cereal boxes, candy wrappers, half gallon jugs of orange juice, cups, or anything else you see in print, most designers are going to use vectorised programs to make these things come to life. Vectors are wonderful because they print extremely well, and you can scale them up to make them large, or scale them down to make them small, and there is no distortion. Adobe Illustrator is the King of Vector Programs, hands down. In Adobe Illustrator, you can create a 12 foot, by 12 foot document. If we are going to make anything that is going to be printed, we are doing it in Illustrator. Anything that you create in Illustrator, and the text you use, will come out great. The thing is, Illustrator is hard to learn. It is not an intuitive program at all. This is because vectors use control points called paths and anchor points. To someone new, they are hard to understand, find, and control. That’s another story. If you are making a poster, you would make your logo, artwork and text in Illustrator. You would still manipulate your images in Photoshop, and then, “place” them to the Illustrator.

☞ Check Your Progress 1

1) What are the application areas of Computer Graphics. Write short notes on each.

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2) What are the file formats available for Presentation Graphics?

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3) Write the full form of (1) TIFF (2) PNG.

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4) Differentiate between Drawing and Painting.

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5) What is Adobe Illustrator used for?

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6) Give some softwares that are suitable for Page Lay out generators like multipage menu for a restaurant?

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7) Is Powerpoint the only presentation graphics software available? If no, then, name some softwares and their developers otherwise provide features of the Powerpoint softwares.

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1.3.3 Photo Editing

Photo-editing programs are paint programs—it's just that they include many sophisticated functions for altering images and for controlling aspects of the image, like light and colour balance.

For the most part, any paint program can open and display a digital photo image, but it will probably not offer the range and depth of features that a true photo-editing program like PhotoShop does.

Note: KidPix is a general graphics program and PhotoShop is an image-editing program. PhotoShop is the standard used by almost all professional artists and image editors. Key graphic application involves image editing or manipulation, No matter what type of design you are creating, you are going to manipulate some images. You might change the content of the images, crop, resize, touchup, falsify, fade in, fade out, and/or whatever. Anything that you are going to do to change an image will get done in an image editing or image manipulation application.

There are three big players in image manipulation:

1) PhotoShop (Adobe)
2) FireWorks (Macro Media)
3) Corel (owned by Corel)

Almost everything you see in print or on the web has gone through PhotoShop. It is the king of image manipulation. With PhotoShop you can make anything look real. Photoshop comes bundled with a program called, “ImageReady”.

ImageReady helps your created animated gif, web site rollover effects, image maps and more. Most people that own PhotoShop use less than 10 per cent of its powerful tools.

Fireworks is a super image manipulation application. The thing is, if you open the program, many of the icons, the tool bar, the panels and many of the options in the drop down menus look just like options in PhotoShop. It kind of looks like somebody copied the other persons application.

Note:

- Video editing is in a new and revolutionary stage. Computers really weren’t ready to edit video affordably until right now. Right now, if you have a fast computer and a lot of storage memory, you can create video segments just like anything you see on TV. And, it works well. I would say that the most popular video editing programs are:

  IMovie (apple. Not the best, but easy to use.)
  Adobe Premiere (Adobe)
  Final Cut Pro (Apple)
  Studio Version 9 (Pinnacle Systems)

- **Web Design and Editing**

  To make and edit a website, the big three softwares are:

  1) DreamWeaver (MacroMedia)
  2) Frontpage (MicroSoft)
  3) Go Live (Adobe)
  4) Netscape Composer (Netscape).

Most web developers use DreamWeaver. It is a super tool. It will write your html, css, javascript and create your forms. It is the best.

Frontpage is known for writing lots of code that you don’t need. Go Live is great, but I have never met a person that uses it.

We listed Netscape Composer basically because it is free. It’s not a bad product for free. We teach a lot of people, “Intro do web design,” and if they don’t have any software to make web pages, and if they don’t want to learn html, we show them Composer.

1.3.4 Scientific Visualisation

It is difficult for the human brain to make sense out of the large volume of numbers produced by a scientific computation. Numerical and statistical methods are useful for solving this problem. Visualisation techniques are another approach for interpreting large data sets, providing insights that might be missed by statistical methods. The pictures they provide are a *vehicle for thinking* about the data.

As the volume of data accumulated from computations or from recorded measurements increases, it becomes more important that we be able to make sense out of such data quickly. Scientific visualisation, using computer graphics, is one way to do this.

Scientific visualisation involve interdisciplinary research into robust and effective computer science and visualisation tools for solving problems in biology, aeronautics, medical imaging, and other disciplines. The profound impact of scientific computing upon virtually every area of science and engineering has been well established. The increasing complexity of the underlying mathematical models has also highlighted the critical role to be played by Scientific visualisation. It, therefore, comes as no surprise that Scientific visualisation is one of the most active and exciting areas of Mathematics and Computing Science, and indeed one which is only beginning to mature. Scientific visualisation is a technology which helps to explore and understand scientific phenomena visually, objectively, quantitatively. Scientific visualisation allow scientists to think about the unthinkable and visualise the unviable. Through this we are seeking to understand data. We can generate beautiful pictures and graphs; we can add scientific information (temperature, exhaust emission or velocity) to an existing object thus becoming a scientific visualisation product.

Thus, we can say scientific visualisation is a scientists tool kit, which helps to simulate insight and understanding of any scientific issue, thus, helping not only in solving or analysing the same but also producing appropriate presentations of the same. This concept of scientific visualisation fits well with modeling and simulation. The *Figure 1* describes steps for visualisation of any scientific problem under consideration, these steps are followed recursively to visualize any complex situation.

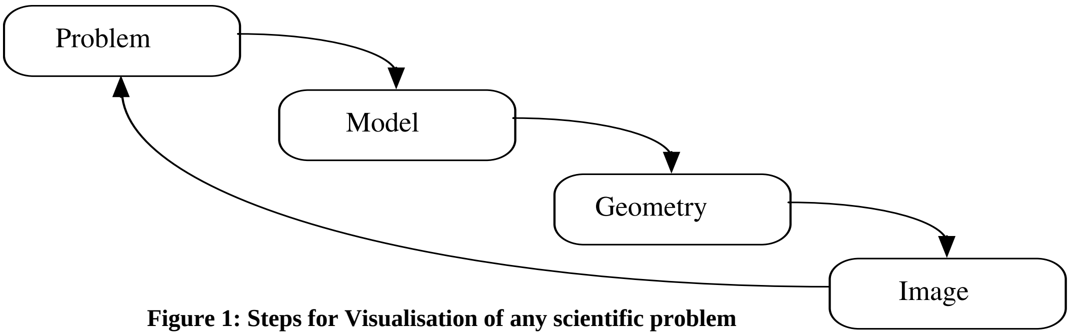

Figure 1: Steps for Visualisation of any scientific problem

Hence, *computer graphics* has become an important part of scientific computing. A large number of software packages now exist to aid the scientist in developing graphical representations of their data. Some of the tools or packages used to express the graphical result for modeling and simulation of any scientific visualisation are:

Matlab (by The Math Works Inc.)

Mathematica or Maple (graphical computer algebra system)

Stella (models dynamic systems)

IDS (Interactive Data Systems) by Research System Inc.

AVS (Application Visualisation System) by Advance visual System Inc.

Excel.

1.3.5 Image Processing

Modern digital technology has made it possible for the manipulation of multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goal of this manipulation can be divided into three categories:

1) Image Processing *image in* -> *image out*
2) Image Analysis *image in* -> *measurements out*
3) Image Understanding *image in* -> *high-level description out*

We will focus on the fundamental concepts of *image processing*. We can only make a few introductory remarks about *image analysis* here, as to go into details would be beyond the scope of this unit. *Image understanding* requires an approach that differs fundamentally from the theme of this section. Further, we will restrict ourselves to two-dimensional (2D) image processing although, most of the concepts and techniques that are to be described can be extended easily to three or more dimensions.

We begin with certain basic definitions. An image defined in the "real world" is considered to be a function of two real variables, for example, $a(x,y)$ with a as the amplitude (e.g., brightness) of the image at the *real* coordinate position (x,y). An image may be considered to contain sub-images sometimes referred to as *regions-of-interest*, *ROIs*, or simply *regions*. This concept reflects the fact that images frequently contain collections of objects each of which can be the basis for a region. In a sophisticated image processing system it should be possible to apply specific image processing operations to selected regions. Thus, one part of an image (region) might be processed to suppress motion blur while another part might be processed to improve colour rendition.

The amplitudes of a given image will almost always be either real numbers or integer numbers. The latter is usually a result of a quantisation process that converts a continuous range (say, between 0 and 100%) to a discrete number of levels. In certain image-forming processes, however, the signal may involve photon counting which implies that the amplitude would be inherently quantised. In other image forming procedures, such as magnetic resonance imaging, the direct physical measurement yields a complex number in the form of a real magnitude and a real phase.

A digital image $a[m,n]$ described in a 2D discrete space is derived from an analog image $a(x,y)$ in a 2D continuous space through a *sampling* process that is frequently referred to as digitisation.

Let us discuss details of digitization. The 2D continuous image $a(x,y)$ is divided into *N rows* and *M columns*. The intersection of a row and a column is termed a *pixel*. The value assigned to the integer coordinates $[m,n]$ with $\{m=0,1,2,...,M-1\}$ and $\{n=0,1,2,...,N-1\}$ is $a[m,n]$. In fact, in most cases $a(x,y)$ – which we might consider to be the physical signal that impinges on the face of a 2D sensor – is actually a function of many variables including depth (z), colour (λ), and time (t). The effect of digitisation is shown in *Figure 2*.

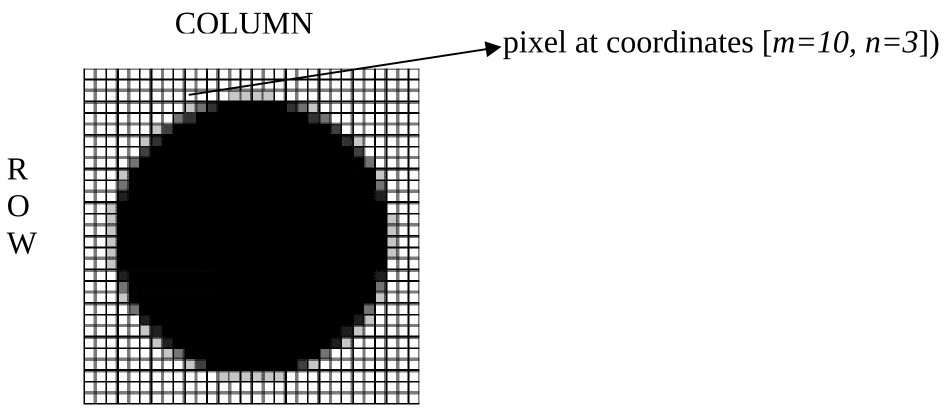

Figure 2: The effect of digitization

The image shown in *Figure 1* has been divided into N = 30 rows and M = 30 columns for digitisation of a continuous image. The value assigned to every pixel (pixel at coordinates [m=10, n=3]) is the average brightness in the pixel rounded to the nearest integer value. The process of representing the amplitude of the 2D signal at a given coordinate as an integer value with L different gray levels is usually referred to as amplitude quantisation or simply quantisation.

Example Tools and Software for Image Processing

Certain tools are central to the processing of digital images. These include mathematical tools such as *convolution*, *Fourier analysis*, and *statistical* descriptions, and manipulative tools such as *chain codes* and *run codes*. But these tools are worked with at very core levels, in general we use some software to process the image with the help of computers. Some of the categories of image processing software with their respective examples and features are listed below:

1) ***Graphics Image Processing:*** The most commonly used software is: Photoshop.

Features:
- Most common image processing software.
- Focuses on creating a pretty picture.
- Usually limited to popular graphics formats such as: TIFF, JPEG, GIF
- Best suited for working with RGB (3-band) images.
- Does not treat an image as a “map”.

2) ***Geographic Information Systems (GIS):*** The most commonly used software is: ArcMap.

Features:
- Works within a geographic context.
- Great for overlaying multiple vector and raster layers.
- It has a somewhat limited analysis although capability, these limitations are being reduced.
- More common than remote sensing software.

3) ***Remote Sensing Packages:*** Commonly used software example is: ERDAS

Features:
- Best suited for satellite imagery.
- Uses geo-spatial information.
- Easily works with multi-spectral data.
- Provides analysis functions commonly used for remote sensing applications.
- Often easy to use but it helps to be familiar with remote sensing.

4) ***Numerical Analysis Packages:*** Commonly used software is: MatLab.

Features:
- Focus usually on numeric processing.
- Programming or mathematical skills usually helpful.
- Used to build more user-friendly applications.

5) ***Web-based Services:*** Commonly used software is: Protected Area Archive.

Features:
- Image display, roam, zoom.
- Image enhancement.
- Simple image processing.

- Distance and area measurement.
- Comparison of old and new images.
- Image annotation (adding text, lines, etc).
- Overlaying vector layers.

Note:

1) Images are the final product of most processes in computer graphics. The ISO (International Standards Organization) defines computer graphics as the sum total of methods and techniques for concerning data for a graphics device by computer, it summarise computer graphics as converting data into images, also called visualisation.

Data → Image

2) Computer graphics concerns the pictorial synthesis of real or imaginary objects from their computer-based models, whereas the related field of image progressing treats the converse process, analysing and reconstruction of sciences. Images processing has sub-areas image enhancement, pattern detection and recognition. This one is used to improve the quality of images by using pattern detection and recognition. OCR is one of example.

1.3.6 Education, Training, Entertainment and Computer Aided Design (CAD)

CAD (or CADD) is an acronym that, depending on who you ask, can stand for:

- Computer Aided Design.
- Computer Aided Drafting.
- Computer Assisted Design.
- Computer Assisted Drafting.
- Computer Assisted Design and Drafting.
- Computer Aided Design and Drafting.

In general acronym for CAD is C*omputer-Aided Design*. In CAD interactive graphics is used to design components and systems of mechanical, electrical, and electronic devices. Actually CAD system is a combination of hardware and software that enables engineers and architects to design everything from furniture to airplanes. In addition to the software, CAD systems require a high-quality graphics monitor; a mouse, light pen or digitised tablets for drawing; and a special printer or plotter for printing design specifications.

CAD systems allow an engineer to view a design from any angle with the push of a button and to zoom in or out for close-ups and long-distance views. In addition, the computer keeps track of design dependencies so that when the engineer changes one value, all other values that depend on it are automatically changed accordingly.

Generally we use CAD as a tool for imparting education and training to the engineers, so that, they can produce beautifully carved and engineered pieces in bulk with the same amount of finishing and perfection. Generally a few terms are used repeatedly with CAD and they are CAM and CNC. Let us discuss **"What are CAD/CAM and CAD/CNC(or NC)"?**

The term CAD/CAM is a shortening of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM). The term CAD/NC (Numerical Control) is equivalent in some industries.

CAD/CAM software uses CAD drawing tools to describe geometries used by the CAM portion of the program to define a tool path that will direct the motion of a machine tool to machine the exact shape that is to be drawn on the computer. Let us discuss the terms in brief.

Note:

- **Numerically-Controlled Machines:** Before the development of Computer-aided design, the manufacturing world adopted tools controlled by numbers and letters to fill the need for manufacturing complex shapes in an accurate and repeatable manner. During the 1950s these Numerically-Controlled machines used the existing technology of paper tapes with regularly spaced holes punched in them (think of the paper roll that makes an old-fashioned player piano work, but only one inch wide) to feed numbers into controller machines that were wired to the motors positioning the work on machine tools. The electro-mechanical nature of the controllers allowed digital technologies to be easily incorporated as they were developed. NC tools immediately raised automation of manufacturing to a new level once feedback loops were incorporated (the tool tells the computer where it is, while the computer tells it where it should be).

  What finally made NC technology enormously successful was the development of the universal NC programming language called APT (Automatically Programmed Tools). Announced at MIT in 1962, APT allowed programmers to develop postprocessors specific to each type of NC tool so that, the output from the APT program could be shared among different parties with different manufacturing capabilities.

  Now-a-days many new machine tools incorporate CNC technologies. These tools are used in every conceivable manufacturing sector, like CNC technology is related to Computer Integrated Manufacturing (CIM), Computer Aided Process Planning (CAPP) and other technologies such as Group Technology (GT) and Cellular Manufacturing. Flexible Manufacturing Systems (FMS) and Just-In-Time Production (JIT) are made possible by Numerically-Controlled Machines.

CAD and CAM

The development of Computer-aided design had little effect on CNC initially due to the different capabilities and file formats used by drawing and machining programs. However, as CAD applications such as SolidWorks and AutoCad incorporate CAM intelligence, and as CAM applications such as MasterCam adopt sophisticated CAD tools, both designers and manufacturers are now enjoying an increasing variety of capable CAD/CAM software. Most CAD/CAM software was developed for product development and the design and manufacturing of components and moulds, but they are being used by architects with greater frequency. Thus, a CAD program introduces the concept of real-world measurement. For example, a car or building can be drawn as if it were life-size, and later arranged into sheets and printed on paper at any desired scale.

Note:

1) CAD (or CADD) stands for Computer-Aided Design and Drafting. It differs from both "paint" and "draw" programs in that (i.e., CAD) measurement is central to its abilities. Whereas a "paint" program lets you manipulate each pixel in an array of pixels that make up an image, and a "draw" program goes a step further – it is composed of separate entities or objects, such as circles, lines, etc. It may provide facilities to group these into any object.

2) Is CAD only useful for design drawings?

   No. While true-scale, structurally valid drawings are the reason for CAD's existence, its use is as diverse as our customer's imaginations. For instance, it may be used for:

(a) page layout, web graphics (when scaling and relationships are important to an image, making the image in CAD and exporting it as a bitmap for touchup and conversion can be very productive),

(b) visually accessed databases (imagine a map with detail where you can zoom into an area and edit textual information "in place" and you can then see what other items of interest are "in the neighborhood" - our program's ability to work very rapidly with large drawings is a real plus here),

(c) sign layout, laser-cutting patterns for garment factories, schematic design (where CAD's symbol library capabilities come in handy), and printed-circuit board layout (This was the application that our first CAD program, created in 1977).

Software packages for CAD applications typically provide designer with a multi-window environment. Animations are often used in CAD application, Real-time animations using wire frame displays on a video monitor are useful for testing the performances of a vehicle or a system. The inter frame system allows the user to study the interior of the vehicle and its behaviour. When the study of behaviour is completed, realistic visualising models, surface rendering are used for background scenes and realistic display.

There are many CAD software applications. Some of them with their respective vendors are listed below:

CAD Applications	**Scanner Vendor: Desktop**
AlphaCAM	Canon
Ashlar Vellum	Epson
AutoCAD	Hewlett Packard
CATIA/CADCAM	UMAX

CAD Applications	**Scanner Vendor: Large Format**
Eagle point	Action Imaging
FastCAD	Contex
Pro/E	Xerox
FelixCAD	Kip
IntelliCAD	Ricoh
MasterCAM	Vidar
MasterStation	Widecom

There are many more applications not listed in the list given above.

These applications replicate the old drafting board as a means to draw and create designs. As CAD applications run on computers they provide a great deal more functionality than a drafting board, and a great deal more complexity. The lines and text created in CAD are **vectors**. This means that their shapes and positions are described in mathematical terms. **These vectors are stored on computer systems in *CAD files.***

There are a great **many different file formats for CAD**. Most CAD applications produce their own proprietary file format. The CAD applications from AutoDesk Inc. are used widely. As a result their DWG format is very common. Many other CAD applications from other vendors can produce and open DWG files, as well as their own proprietary formats. CAD data is often exchanged using DXF format.

Note: The DWG file format is a CAD vector format developed by the Autodesk and created by their AutoCAD application. DXF is also a CAD vector format. It is designed to allow the exchange of vector information between different CAD applications. Most CAD applications can save to and read from DXF format.

When CAD drawings are sent to printers the format commonly used is HPGL. HPGL files typically have the extension .plt.

Note: The HPGL file format is a vector format developed by Hewlett Packard for driving plotters. The file extensions used include .plt, .hpg, .hp2, .pl2 and sometimes .prn. However, the use of the .prn extension is not an absolute indicator that the file contains HPGL code. They are often referred to as 'plot files'. Trix Systems offers several options for handling HPGL and the later HPGL2 file formats.

☞ Check Your Progress 2

1) What is Photo Editing? What are the softwares used for image editing?

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2) What do you understand by term scientific visualisation, name some software used in this area?

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3) What is image processing? Give some areas of importance is which the concept of image processing is of use also mention the fruitful softwares in the respective fields.

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4) Is CAD useful only for designing drawings?

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5) Briefly discuss DWG, DXF, formats and HPGL files.

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1.3.7 Simulations

Computer simulation is the discipline of designing a model of an actual or theoretical physical system, executing the model on a digital computer, and analysing the execution output. Simulation embodies the principle of "learning by doing" – to learn about the system we must first build a model of some sort and then operate the model. The use of simulation is an activity that is as natural as a child who *role plays*. Children understand the world around them by simulating (with toys and figures) most of their interactions with other people, animals and objects. As adults, we lose some of this childlike behaviour but recapture it later on through computer simulation. To understand reality and all of its complexity, we must build artificial objects and dynamically act our roles with them. Computer simulation is the electronic equivalent of this type of role playing and it serves to drive synthetic environments and virtual world. Within the overall task of simulation, there are three primary sub-fields: model design, model execution and model analysis (*Figure 3*).

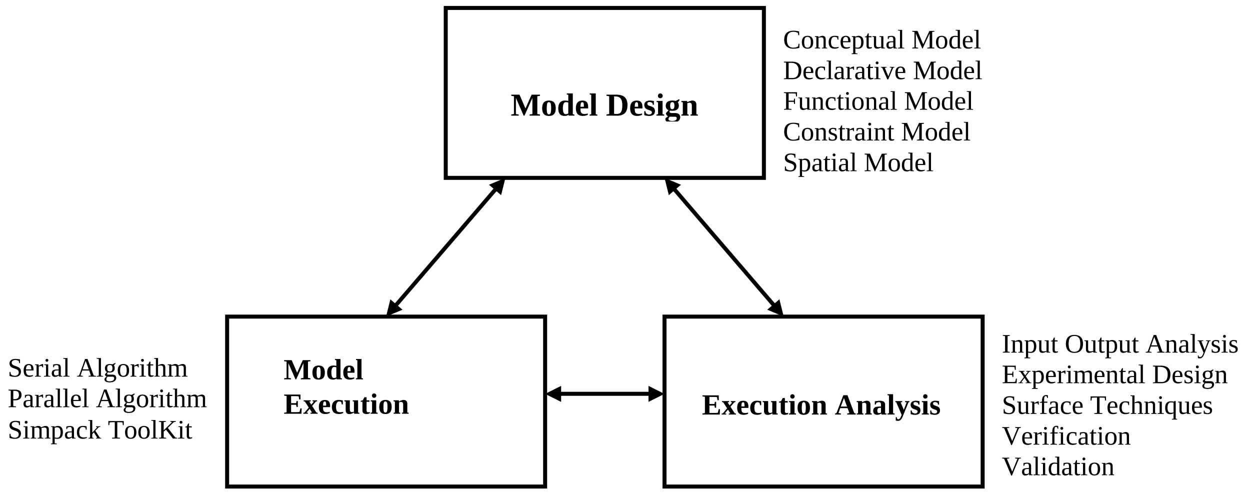

Figure 3: Three Sub-Fields of Computer Simulation

To simulate something physical, you will first need to create a *mathematical model,* which represents that physical object. Models can take many forms including declarative, functional, constraint, spatial or multimodel. A multimodel is a model containing multiple integrated models each of which represents a level of granularity for the physical system. The next task, once a model has been developed, is to execute the model on a computer – that is, you need to create a computer program which steps through time while updating the state and event variables in your mathematical model. There are many ways to "step through time". You can, for instance, *leap* through time using *event scheduling* or you can employ small time increments using *time slicing*. You can also execute (i.e., simulate) the program on a massively parallel computer. This is called *parallel and distributed simulation*. For many large-scale models, this is the only feasible way of getting answers back in a reasonable amount of time.

You may want to know why to do simulation? Is there any other way to do the tasks? To discuss these issues lets briefly discuss the cases in which simulation is essential. There are many methods of modeling systems which do not involve simulation but which involve the solution of a closed-form system (such as a system of linear equations). Let us not go into these issues, as they are not part of our current discussion.

Simulation is often essential in the following cases:

1) The model is very complex with many variables and interacting components;
2) The underlying variables relationships are nonlinear;
3) The model contains random variates;
4) The model output is to be visual as in a 3D computer animation.

The Advantage of Simulation is that – even for easily solvable linear systems – a uniform model execution technique can be used to solve a large variety of systems without resorting to a "bag of tricks" where one must choose special-purpose and sometimes arcane solution methods to avoid simulation. Another important aspect of the simulation technique is that one builds a simulation model to replicate the actual system. When one uses the closed-form approach, the model is sometimes twisted to suit the closed-form nature of the solution method rather than to accurately represent the physical system. A harmonious compromise is to tackle system modeling with a hybrid approach using both closed-form methods and simulation. For example, we might begin to model a system with closed-form analysis and then proceed later with a simulation. This evolutionary procedure is often very effective.

Pitfalls in computer simulation

Although generally ignored in computer simulations, in strict logic the rules governing floating point arithmetic still apply. For example, the probabilistic risk analysis of factors determining the success of an oilfield exploration program involves combining samples from a variety of statistical distributions using the MonteCarlo methods. These include normal, lognormal, uniform and the triangular distributions. However, a sample from a distribution cannot sustain more significant figures than were present in the data or estimates that established those distributions. Thus, abiding by the rules of significant arithmatic, no result of a simulation can sustain more significant figures than were present in the input parameter with the least number of significant figures. If, for instance the net/gross ratio of oil-bearing strata is known to only one significant figure, then the result of the simulation cannot be more precise than one significant figure, although it may be presented as having three or four significant figures.

Note: *Monte Carlo methods* are a widely used class of computational algorithm for simulating the behaviour of various physical and mathematical systems. They are distinguished from other simulation methods (such as molecular dynamics) by being stochastic, that is non-deterministic in some manner – usually by using random number – as opposed to deterministic algorithms. Because of the repetition of algorithms and the large number of calculations involved, Monte Carlo is a method suited to calculation using a computer, utilising many techniques of computer simulation. Further, *Monte Carlo algorithm* is a numerical Monte Carlo method used to find solutions to mathematical problems (which may have many variables) that cannot easily be solved, for example, by integral calculus, or other numerical methods. For many types of problems, its efficiency relative to other numerical methods increases as the dimensions of the problem increases.

1.3.8 Animation and Games

In our childhood, we have all seen the flip books of cricketers which came free along with some soft drink, where several pictures of the same person in different batting or bowling actions are sequentially arranged on separate pages, such that when we flip the pages of the book the picture appears to be in motion. This was a flipbook (several papers of the same size with an individual drawing on each paper so the viewer could flip through them). It is a simple application of the basic principle of physics called persistence of vision. This low tech animation was quite popular in the 1800s when the persistence of vision (which is $1/16^{th}$ of a second) was discovered. This discovery led to some more interesting low tech animation devices like the zoetrope, wheel of life, etc. Later, depending on many basic mathematics and physics principles, several researches were conducted which allowed us to generate 2d/3d animations. In units 1 and 2 of block 2 we will study the transformations involved in computer graphics but you will notice that all transformations are related to space and not to time. Here lies the basic difference between animation and graphics. The difference is that animation adds to graphics the dimension of time which vastly increases the amount of information to be transmitted, so some methods are used to handle this vast information and these methods are known as animation methods which are classified as:

First Method: In this method, the artist creates a succession of cartoon frames, which are then combined into a film.

Second Method: Here, the physical models are positioned to the image to be recorded. On completion, the model moves to the next image for recording and this process is continued. Thus the historical approach of animation has classified computer animation into two main categories:

(a) *Computer-Assisted Animation* usually refers to 2d systems that computerise the traditional animation process. Here, the technique used is interpolation between key shapes which is the only algorithmic use of the computer in the production of this type of animation equation, curve morphing (key frames, interpolation, velocity control), image morphing.

(b) *Computer Generated Animation* is the animation presented via film or video, which is again based on the concept of persistence of vision because the eye-brain assembles a sequence of images and interprets them as a continuous movement and if the rate of change of pictures is quite fast then it induces the sensation of continuous motion.

This motion specification for computer-generated animation is further divided into 2 categories:

Low Level Techniques (Motion Specific) techniques are used to control the motion of any graphic object in any animation scene fully. Such techniques are also referred as motion specific techniques because we can specify the motion of any graphic object in the scene. Techniques such as interpolation, approximation etc., are used in motion specification of any graphic object. *Low level techniques* are used when animator usually has a fairly specific idea of the exact motion that s/he wants.

High Level Techniques (Motion Generalised) *are techniques* used to describe the general motion behaviour of any graphic object. *These techniques are* algorithms or models used to generate motion using a set of rules or constraints. The animator sets up the rules of the model, or chooses an appropriate algorithm, and selects initial values or boundary values. The system is then set into motion and the motion of the objects is controlled by the algorithm or model. This approach often relies on fairly sophisticated computation such as, vector algebra and numerical techniques among others.

So, the animation concept can be defined as: *A time based phenomenon for imparting visual changes in any scene according to any time sequence. The visual changes could be incorporated through the Translation of the object, scaling of the object, or change in colour, transparency, surface texture etc.*

Note: It is to be noted that computer animation can also be generated by changing camera parameters such as its position, orientation, focal length etc. plus changes in the light effects and other parameters associated with illumination and rendering can produce computer animation too.

Before the advent of computer animation, all animation was done by hand, which involved an enormous amount of work. You may have an idea of the amount of work by considering that each second of animation film contains 24 frames (film). Then, one can imagine the amount of work in creating even the shortest of animated films. Without going into details of traditional methods let us categorise computer animation technique. Computer animation can be categorised in two ways:

Interactive Computer Animation which is interactively used by users e.g., games. Sprite animation is interactive and used widely in Computer games. In its simplest form it is a 2D graphic object that moves across the display. Sprites often have transparent areas. Sprites are not restricted to rectangular shapes. Sprite animation lends itself well to interactivity. The position of each sprite is controlled by the user or by an application program (or by both). It is called "external" animation.We refer to animated objects (sprites or movies) as "animobs". In games and in many multimedia applications, the animations should adapt themselves to the environment, the program status or the user activity. That is, animation should be *interactive*. To make the animations more event driven, one can embed a script, a small executable program, in every animob. Every time an animob touches another animob or when an animob gets clicked, the script is activated. The script then decides how to react to the event
(if at all). The script file itself is written by the animator or by a programmer. We will discuss about this in Block 4.

Passive Computer Animations: which has no option for users to use computer graphics today is largely interactive e.g., movies. Frame animation is non-interactive animation and is generally used in generating Cartoon movies. This is an "internal" animation method, i.e., it is animation inside a rectangular frame. It is similar to cartoon movies: a sequence of frames that follow each other at a fast rate, fast enough to convey fluent motion. It is typically pre-compiled and non-interactive. The frame is typically rectangular and non-transparent. Frame animation with transparency information is also referred to as "cel" animation. In traditional animation, a cel is a sheet of transparent acetate on which a single object (or character) is drawn.We will discuss this in Block 4.

There are various software which are used to generate computer animations. Some of them are:

- **Flash:** Learning MacroMedia's Flash can be quite complex, but you can do almost anything with it. You can develop presentations, websites, portions of websites, games, or full-length feature, animated cartoons.

  You can import just about anything into Flash. You can drop in images of almost any file format, video clips, sounds and more. It is generally a 2D program.

- **Poser:** Poser by Curious Labs Creates 3D complex models that you can view, from any angle, distance or perspective. You can make the model look like any body you want it to. For instance, if you wanted to make a model that looks just like your Grandmother, you would do it in Poser (the learning curve is vast). Taking that to another level, you could then animate your Grandmother and make her run down a picture of a beach.

There are many more software related to this animation, we will discuss them in the Unit 1 of Block 4.

☞ Check Your Progress 3

1) What do you mean by simulation? What are its uses? Discuss the advantages and pitfalls of simulation.

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2) Differentiate between Graphics and Animation.

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1.4 GRAPHICS HARDWARE

No matter with which advance graphic software you are working with, if your output device is not good, or hardware handling that software is not good, then ultimate result will be not good, as it could be. We want to say, hardwares also dominate the world of graphics. So, let us discuss some hardware devices which helps us to work with graphic packages.

1.4.1 Input and Output Devices

Input and Output devices are quite important for any software because an inappropriate selection of the concerned hardware may produce some erroneous results or may process data of some other format. So, in the following sections we have planned to discuss some of the input and output devices such as:

- Touch Panel
- Light Pens
- Graphics Tablet
- Plotters
- Film Recorders.

Touch Panels

Touch panels allow displayed object or screen positions to be selected with the touch of the finger and is also known as Touch Sensitive Screens (TSS). A typical application of touch panels is for the selection of processing options that are represented with graphical icons. Touch input can be recorded using optical electrical or acoustical methods.

Optical touch panels employ a line of intra red LEDS (light emitting diodes) along one vertical edge and along one horizontal edge of frame. The opposite vertical and horizontal edges contain light detection. These detections are used to record the beams that may have been interrupted when the panel was touched. Two crossing beams that are interrupted identify the horizontal and vertical coordinates of screen position selected.

An electrical touch panel is constructed with two transparent plates separated by a short distance. One of the plates is coated with a conducting material and the other is resistive material. When the outer plate is touched, it is forced into contact with the inner plate. The contact creates a voltage drop that is converted to a coordinate value of the selected screen position. They are not too reliable or accurate, but are easy to use. Four types are commonly in use. They are as follows:

1) **Electrical TSS:** Wire grid or other conductive coating is utilised to indicate a voltage drop at the point touched point, from which the position may be determined.

2) **Electro-Mechanical TSS:** A glass or plastic sheet with strain gages placed around the edges records the position by the relative magnitude of the deformation of the slightly bent plate.

3) **Optical TSS:** Infrared light from light-emitting diodes (LED) along two perpendicular edges of the screen and detectors along the opposite edges provide an (invisible) optical grid, with reference to which the finger's position is determined.

4) **Acoustic TSS:** Inaudible high-frequency sound waves are emitted along two perpendicular edges and reflected to the emitters by the finger; the echo interval is used as a measure of the distances from the edges.

Light Pen

Light pen is a pointing device. It has a light sensitive tip which is excited when the light is emitted and an illuminated point on the screen comes in its field of view. Unlike other devices which have associated hardware to track the device and determine x and y values, the light pen needs software support (some kind of tracking program). Pointing operations are easily programmed for light pens.

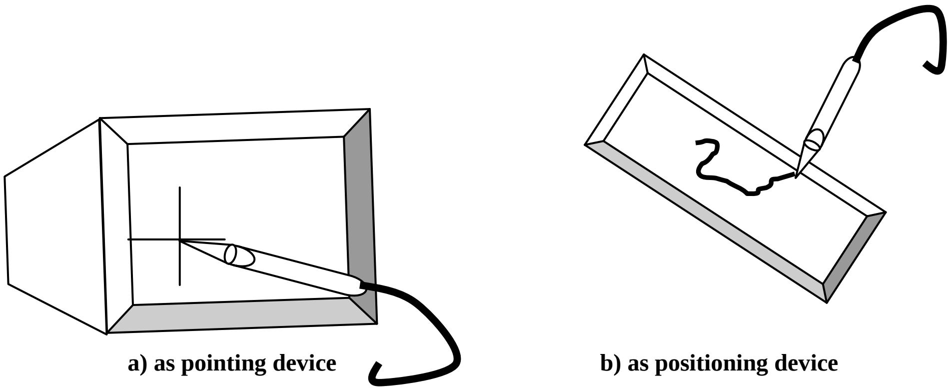

Figure 4: Light Pen Application

Figure 4 shows two typical applications of a light pen. It has a light sensitive tip and a photocell mounted in a pen-like case. If the light pen is pointed at an item on the screen it generates information from which the item can be identified by the program.

When the light pen senses an illuminated phosphor, it interrupts the display processor's interpreting of the file display. The processor's instruction register tells which instruction in the display file was being executed. By identifying the instruction responsible for the illuminated point, the machine can discover which object the pen is pointing to.

A light pen is an **event driven** device. The processor has to wait till it comes across an illuminated point on the screen to obtain any information. The keyboard is another typical example of an event driven device. The processor has to wait for a key to be pressed before it can determine what the user wants to input. Event driven devices can be handled in two ways as follows:

(a) ***Polling:*** The status of each device is periodically checked in a repetitive manner by a polling loop. When an event occurs, the loop is exited and the corresponding event is handled by executing some special event-handling routine or task. Again the polling continues. The disadvantage is that the processor has to wait in an idle state until some event occurs. Data entered can be lost if an event occurs at a time when the main program is not in its polling loop.

(b) ***Interrupts:*** An alternative to polling is the interrupt feature. The device sends an interrupt signal to the processor when an event occurs. The processor breaks from its normal execution and executes some special interrupt-handling routine or task. After the task is complete the control returns to the main program. To handle situations when more than one event occurs, different priorities are assigned to tasks so that higher priority tasks may interrupt tasks of lower priority.

Several events may occur before the program is ready for them. When more than one event occurs, the associate information is entered into the event queue. A polling loop can be employed to check the status of the event queue. The event queue can then pass input data from the polling task to the main program in the correct order. The main program takes events off the head of the queue and invokes the appropriate process. The devices need not be checked repeatedly for occurrence of events. Devices can interrupt even with the processor being unaware of it.

Two kinds of light pen interrupts may occur. If the user points the pen at an item on the screen to select it, as in *Figure 4(a)*, a selection interrupt occurs. If the user is positioning with the pen, as in *Figure 4(b)* a pattern called tracking pattern in displayed along the pen's movement and tracking interrupts occur when the pen sees the tracking pattern.

Modified versions of the light pen may also be used to draw lines, read barcodes, or do transformation operations on objects on the screen (or on a tablet).

Graphics Tablet

Before going into details on the graphic tablet, we need to know what we mean by tablet in computer terminology because, in other disciplines, the word tablet carries different meanings. In terms of computer science "Tablet is a special flat surface with a mechanism for indicating positions on it, normally used as a locator". This small digitiser is used for interactive work on a graphics workstation. Actually this device is essential when someone wants to do free hand drawing or to trace any solid geometrical shape. So a graphic tablet is a drawing tablet used for sketching new images or tracing old ones. Or we may say that a **graphics tablet** is a computer input device that allows one to hand-draw images and graphics, similar to the way one draws images with a pencil on paper. Or a Graphics tablet is a computer peripheral device that allows one to hand images directly to a computer, generally through an imaging program. Graphics tablets consists of a flat surface upon which the user may 'draw' an image using an attached pen-like drawing apparatus using which the user contacts the surface of the tablet, this apparatus is categorised into two types known as pen (or stylus) and puck (a flat block with cross-hairs and some switch keys), which may be wired or wireless. Often mistakenly called a mouse, the puck is officially the "tablet cursor." The image drawn or traced generally does not appear on the tablet itself but rather is displayed on the computer monitor.

The tablet and a hand-held pointer in the form of a stylus (pen) or puck, can serve one or more of these three functions:

(i) For selecting positions (on a drawing or on a menu) on the screen by moving the stylus on the tablet, in a sense using the stylus and tablet as pen on paper.

(ii) For issuing a command or to input a parameter by pressing the stylus at specified pre-programmed locations of a menu on the tablet.

(iii) For digitising the location on a drawing or map placed on the tablet with the stylus or puck.

This device is more accurate and efficient than a light pen. These are two types in use:

(a) **Voltage or Electro-Magnetic Field Tablet and Pointer:** This has a grid of wires, embedded in the tablet surface, with different voltages or magnetic fields corresponding to different coordinates. Intermediate positions within a cell can also be interpolated.

(b) **Acoustic or Sonic (Radio-Wave) Tablet and Pointer:** The sound of a spark at the tip of the stylus is picked up by strip microphones along two edges of the tablet. From the arrival time of the sound pulse at the microphones, the perpendicular distances of the stylus tip from the two axes are known. The acoustic method suffers from its inherent noisiness as well as its susceptibility to interference from other noise.

A combination of electric pulses and time-delay detection by a sensor in the stylus, called **Electro-acoustic Table** is also available.

Tablets typically support two modes of operation:

1) **Digitiser Mode:** creates a one-for-one correspondence between tablet and screen. Wherever you make contact on the tablet, is the exact location on the screen that is affected.

2) **Mouse Mode:** Mouse mode moves the screen pointer relative to any starting position on the tablet surface, just like a mouse.

When drawing or tracing on the tablet, a series of x-y coordinates (vector graphics) are created, either as a continuous stream of coordinates, or as end points. Further the drawings created or traced on tablets are stored as mathematical line segments; and these features of tablets help to produce, tablet computers, tablet PCs and pen tablets.

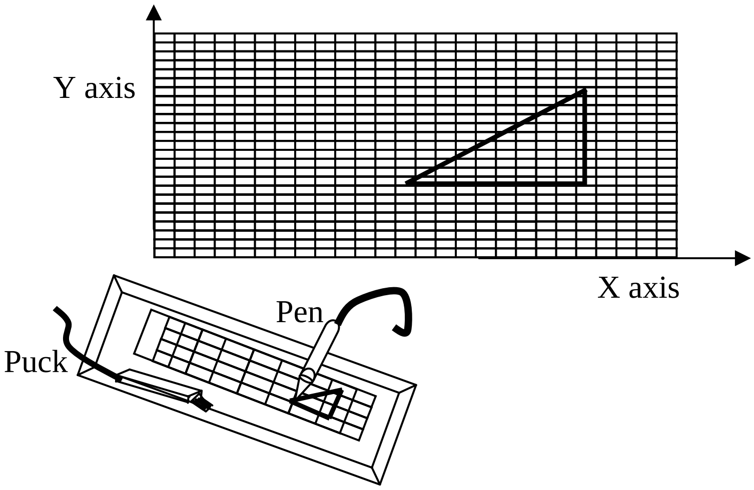

Figure 5: Graphic Tablet

Note: Objects are drawn with a pen (or stylus) or puck, but are traced with the puck only.

Tablet Computer: A complete computer contained in a touch screen. Tablet computers can be specialised for only Internet use or be full-blown, general-purpose PCs with all the bells and whistles of a desktop unit. The distinguishing characteristic is the use of the screen as an input device using a stylus or finger. In 2000, Microsoft began to promote a version of Windows XP for tablet computers, branding them “Tablet PCs”.

Pen Tablet: A digitiser tablet that is specialised for handwriting and hand marking. LCD-based tablets emulate the flow of ink as the tip touches the surface and pressure is applied. Non-display tablets display the handwriting on a separate computer screen.

Plotter: A plotter is a vector graphics-printing device that connects to a computer. Now-a-days, we use the plotter right from the field of engineering, to media and advertising. Even in our day-to-day lives we see a large number of computer designed hoardings and kiosks as publicity material. This fine output is achieved by using plotters with computers.

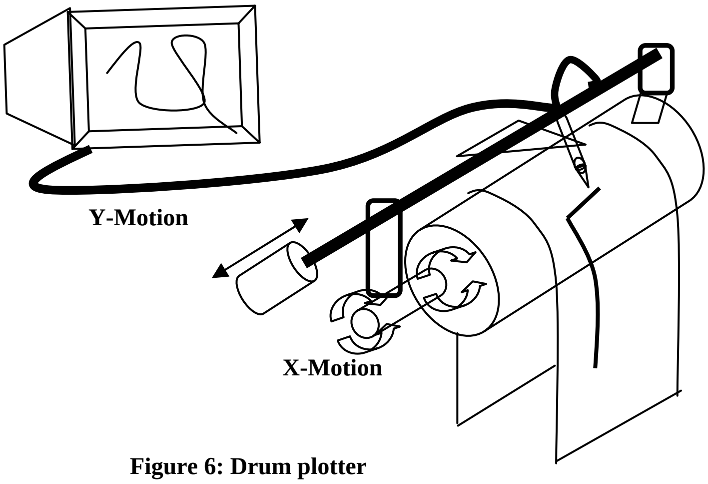

Figure 6: Drum plotter

But the printer may also be connected to the computer. The question then arises, as to how they differ from each other. So let us discuss the differences between them.

1) Plotters print their output by moving a pen across the surface of a piece of paper. This means that plotters are restricted to line art, rather than raster graphics as with other printers. They can draw complex line art, including text, but do so very slowly because of the mechanical movement of the pen.

2) Another difference between the plotter and the printer is that, the printer is aimed primarily at printing text. Thus, the printer is enough to generate a page of output, but this is not the case with the line art of the plotter.

Film Recorders

Film recorder is a graphical output devices for transferring digital images to photographic films.The simplest film recorders typically work by displaying the image on a grayscale Cathode Ray Tube (CRT) placed in front of a photographic camera. For colour images, the red, green, and blue channels are separately displayed on the same grayscale CRT, and exposed to the same piece of film through a filter of the appropriate colour. (This approach yields better resolution and colour quality than one could obtain with a colour CRT). The three filters are usually mounted on a motor-driven wheel. The filter wheel, as well as the camera's shutter, aperture, and film motion mechanism are usually controlled by the recorder's electronics and/or the driving software.

Higher-quality film recorders called LVT (Light Value Transfer) use laser to write the image directly onto the film, one pixel at a time. This method is better suited to print to large-format media such as poster-size prints. In any case, the exposed film is developed and printed by regular photographic chemical processing. Self-developing (polaroid) film can be used for immediate feedback.

Film recorders are used in digital printing to generate master negatives for offset and other bulk printing processes. They are also used to produce the master copies of movies that use computer animation or other special effects based on digital image processing. For preview, archiving, and small-volume reproduction, film recorders have been rendered obsolete by modern printers that produce photographic-quality hardcopies directly on plain paper.

Film recorders were also commonly used to produce slides for slide projectors; but this need is now largely met by video projectors that project images straight from a computer to a screen.

Film recorders were among the earliest computer graphics output devices. Nowadays, film recorders are primarily used in the motion picture film-out process for the ever increasing amount of digital intermediate work being done. Although significant advances in large venue video projection alleviates the need to output to film, there remains a deadlock between the motion picture studios and theatre owners over who should pay for the cost of these very costly projection systems. This, combined with the increase in international and independent film production, will keep the demand for film recording steady for at least a decade.

☞ Check Your Progress 4

1) What is a graphics tablet? How do the components of a graphic tablet i.e., Pen and Puck differ?

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2) What are touch panels? Discuss different touch panels that are currently available for use?

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3) How does a printer differ from a plotter?

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4) What are file recorders?

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1.4.2 Display Devices

As the importance of input and output devices has been discussed above, let us now focus our discussion specifically on display devices, which present the output to the end user who may not be a technically sound client. If the output display is appealing then your creation will definitely receive a word of appreciation otherwise you may be at the receiving end. Hence, it is pertinent to discuss some of the display devices next.

Refreshing Display Devices

Cathode Ray Tube: It is a refreshing display device. The concept of a refreshing display is depicted pictorially below:

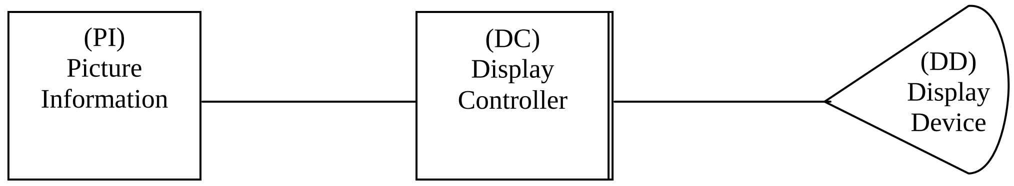


Figure 7: Block Diagram of Display Device

Actually the picture information is given through the stream of electrons (e^-) and its flow is controlled by the display controller (the control is as per the information supplied by the picture) finally the controlled e^- flow produces scintillations on the screen of the display device and the image is formed. The display is known as a refreshing display because display is continuously created by the continuous impugnation/striking of electrons on the screen at the same point. (i.e., same image is continuously made 40-50 times per second i.e., continuous refreshing occurs).

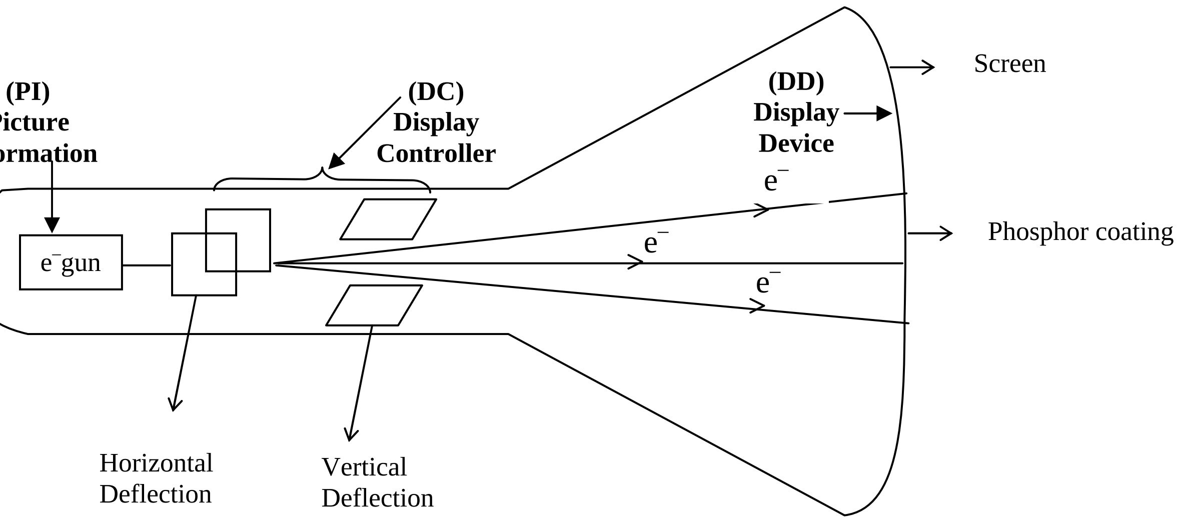


Figure 8: CRT

For proper image we also need to implant a "Digital to Analog converter" (**DAC –** it is an electronic circuit for digital to analog conversion) between the display controller and the display device.

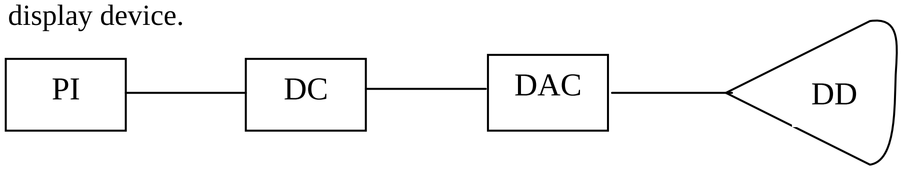


Figure 9: Block Diagram of Display Device with DAC

There are two kinds of refresh monitors, namely, the Random Scan and Raster Scan, which will be described separately.

Note:

1) In a Random Scan System, the Display buffer stores the picture information. Further, the device is capable of producing pictures made up of lines but not of curves. Thus, it is also known as "Vector display device or Line display device or Calligraphic display device".

2) In a Raster Scan System, the Frame buffer stores the picture information, which is the bit plane (with m rows and n columns).

Because of this type of storage the system is capable of producing realistic images, but the limitation is that, the line segments may not appear to be smooth.

Random Scan Display Device

The original CRT, developed in the late fifties and early sixties, created charts and pictures, line by line on the tube surface in any (*random*) order or direction given, in a vectorial fashion. The electron beam was moved along the particular direction and for the particular length of the line as specified. For this reason, the type of device was known as a **Vector, Calligraphic** or **Stroke** (because it drew lines just as our ancestors drew letters like pictures, stroke by stroke). The process was similar to a hand-sketch or pen-plot.

The graphics commands are transmitted to a display-file program generated by the computer and stored in the **refresh storage area** or buffer memory. The program is executed once in each refresh cycle (of about 1/30 sec.) The electron beam is moved to trace the image line-by-line by a **display processor.** Each line, whether straight or curved, is displayed by the activation of specific points between specified end-point by means of **vector generators** of the analog or digital type, the former being smoother, the latter being faster and cheaper. Curved lines and text characters are displayed as a series of short lines or by a sequence of points.

The display by this system is called **Line Drawing Display.** The sequence operates the following stages, illustrated in *Figure 10*:

1) Graphics Commands
2) Display-File Translator
3) Display-File Program
4) Display (File) Processor
5) VDU

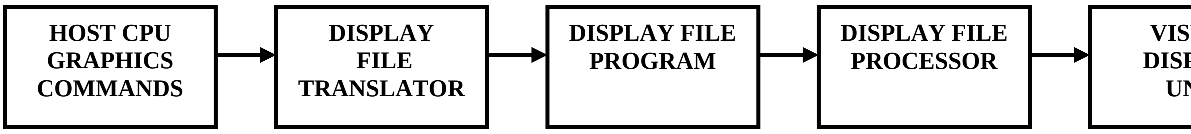
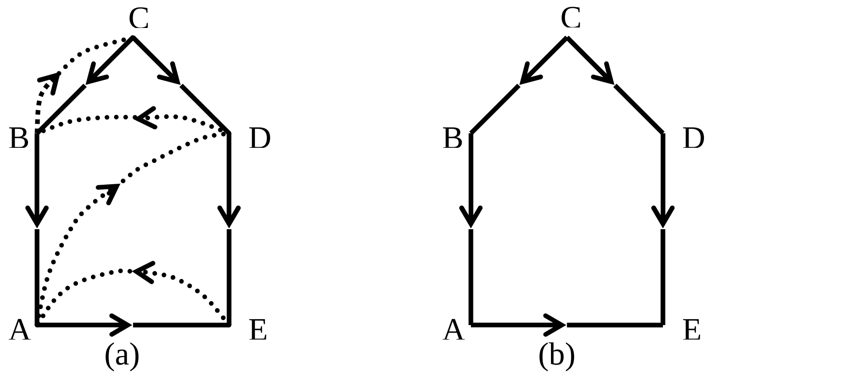


Figure 10: Block Diagram of Line Drawing Display

The process is quite similar to the way a person or a plotter draws a line segment, the pen being moved along a certain direction for a certain length, then changing direction or lifting the pen and moving to a new point, and so on.

For instance, the image of a hut shown in *Figure 11* would be traced as five line segments, the left and right roof slopes, the left and right walls, and the floor line. Efficiency is achieved by minimising wasted motion as would happen if a line segment starts at a point different from the end point of the previous segment – mequivalent to picking up the pen and putting it down at another point to draw the next segment. Thus, it would be better to trace the hut as ABCDE, rather than as CB, CD, BA, DE, and AE, as a draftsman might draw.



a) CB-CD-BA-DE-AE **b) ABCDEA (--- beam off, beam on)**

Figure 11: Vector Scan Display

Raster Scan Display Device

Current day screen display is also based on CRT technology, except that instead of displaying the picture tracing along one vector after another, the image is displayed as a collection of phosphor dots of regular shape arranged in a matrix form. These regular shapes are the pixels (picture elements) and cover the entire screen. The pixels could be (as in earlier times) rectangular, round, or (as is common now) square.
A pixel is the smallest unit addressable by the computer and is made up of a number of smaller dots, comprising the smallest phosphor particles in the CRT coating. However, in this text, we shall use the word "dot" synonymously with "pixel".
The reasons as to why the original CRT did not become popular with the people using computer was because, the refresh procedure required a large memory and high speed, and the equipment to provide these was too expensive. It had to yield to the cheaper storage tube display.

Advances in television technology and chip memories in the mid-seventies overcame both problems with the development of the **raster display**, in which the picture was formed not directly by the lines forming the image but by a choice of appropriate dots from the array of pixels, the entire collection being called the **Raster.** Each row of pixels is called a **Raster Line,** or **Scan Line**.

The electron beam covers the display area horizontally, row by row, from top to bottom in a sweeping motion called **Raster Scan**, each dot lighting up with the intensity and shade of gray or a colour as directed by the Display Controller. Each complete sweep from top left to bottom right of the screen is one complete cycle, called the **Refresh Cycle**.

When viewed from a distance, all the dots together make up the effect of a picture, whether it is a scene from a serial as in the TV or a drawing in computer graphics. The picture looks smooth or coarse-grained depending on the screen **resolution**, that is the number of dots. Typically, on a computer monitor, there are 640 dots in the horizontal direction and 200 to 480 dots in the vertical direction. (The home TV is much finer grained, about three times or more, the scanning being done with analog signals for an entire line at a time, as against the digital information for each dot in the computer monitor). Today's monitors can have resolutions of 1024 by 768 or even higher.

Even with the advent of raster scan, the concept of vector (random scan) graphics has not been completely eliminated. Certain standard geometric shapes such as straight-line segments, circles and ellipses are built into compilers and packages as equations, and developed into pixel graphics for the particular size and parameters specified. Similarly, and more recently, even many fonts in text typography have been reduced to equations so that the input letters, number etc. are really *drawn* from computed lines, as a form of vector graphics. Before going into more details on raster scan display device, let us discuss what is **Raster Scan**. It is the action, which is very similar to that of a dot matrix printer, or even a typewriter that is used to print a pretty border around a message, one line at a time. The image grows from top to bottom, one line at a time, unit completed only when the last line is printed.

The Raster Scan Proceeds as follows: Starting from the top left corner of the screen, the electron gun scans (sweeps) horizontally from left to right, one scan line, that is, one row at a time, jumping (without tracing the line) to the left end of the next lower row until the bottom right corner is reached. Then it jumps (again without tracing) to the top left corner and starts again, finishing one complete refresh cycle. *Figure 12* shows the track of a raster cycle.

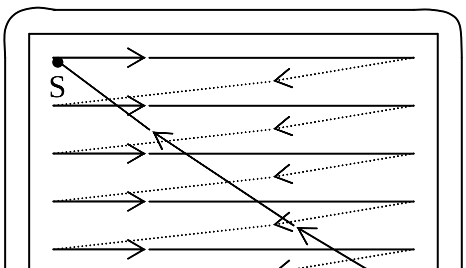


Figure 12: Raster Scan Cycle S-start, E-End

One cycle is completed in about 1/30th of a second, which is faster than the human eye can perceive-thus creating the impression of continuous display and motion.

This technology became very cost-effective, even inexpensive, and because of the availability of large memory and of its high refresh speed, it has become very popular. It takes us back to the refresh-type displays, and especially caters to the interactive and dynamic nature of modern-day computer graphics.

The main disadvantage of the raster scan is the jagged nature of the lines, arising from the fact that the pixels are aligned along regular rows and columns, and points on a line will not, in general, fall on the exact centres of the pixels. But the advantages far outweigh this disadvantage and further developments have diminished this jaggedness problem as well. Hence, almost all the monitors used today have raster display, using pixels, and all subsequent discussions in this text will be concerned with this last type.

All of the preceding characteristics of raster scan will apply to any image on the screen, whether it is graphics proper in the sense of a drawing, or it is a character (letter, number or other symbol).

Three components are necessary for the raster scan display. They are:

1) The **Frame Buffer** which is also called the **Refresh Buffer** or Bitmap. It is the refresh storage area in the digital memory, in which the matrix (array) of intensity values and other parameters (called **attributes**) of all the pixels making up the image are stored in binary form.

2) The display device, which converts the electrical signals into visible images, namely the VDU.

3) The **Display Controller**, the interface that transmits the contents of the frame buffer to the VDU in a form compatible with the display device, a certain number of (30 or more) times a second. The display controller also adjusts and makes allowances for the differences in the operating speeds of the various devices involved, and may also generate line segments and text characters.

Creating points, lines, characters, as well as filling in areas with shades or colours are all accomplished by this scan technique, known as the **Frame Buffer Display.** A common method for storing characters is to store the pixel information for the entire matrix (5*7 to 9*14, horizontal to vertical) assigned to represent a character.

The sequence of operations here is by the following stages, as depicted in *Figure 13.*

1) Graphics Commands
2) Display Processor (Scan Conversion)
3) Frame Buffer
4) Display Controller
5) VDU

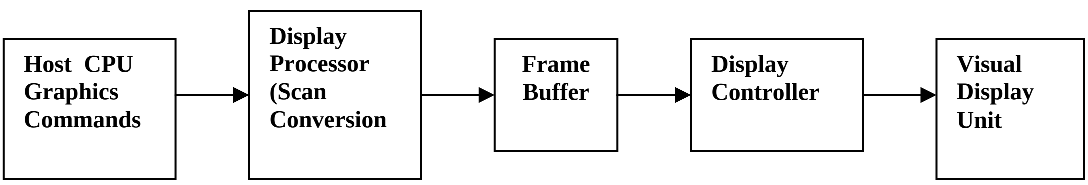


Figure 13: Block diagram of Raster Scan Display Device

Frame Buffers

The storage area in a raster scan display system is arranged as a two-dimensional table. Every row-column entry stores information such as brightness and/or colour value of the corresponding pixel on the screen. In a frame buffer each pixel can be represented by 1 to 24 or more bits depending on the quality (resolution) of the display system and certain attributes of the pixel. Higher the resolution, better the quality of the pictures. Commands to plot a point or line are converted into intensity and colour values of the pixel array or bitmap of an image by a process called **Scan Conversion**.

The display system cycles through the refresh buffer, row-by-row at speeds of 30 or 60 times per second to produce the image on the display. The intensity values picked up from the frame buffer are routed to the Digital/Analog converter which produces the necessary deflection signals to generate the raster scan. A flicker-free image is produced by interlacing all odd-numbered scan lines that are displayed first from, top to bottom and then, all even-numbered scan lines that are displayed. The effective refresh rate to produce the picture becomes much greater than 30 Hz.

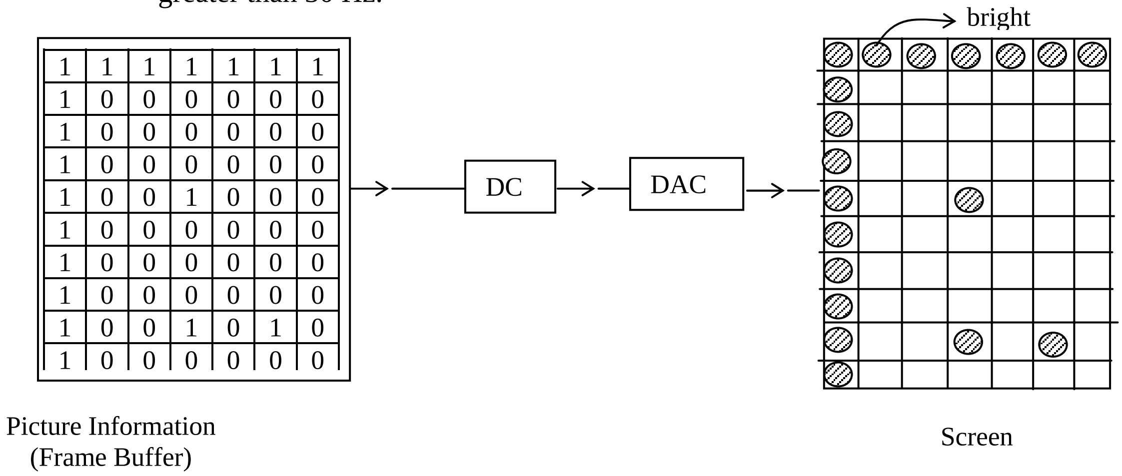


Figure 14: If information stored in frame buffer is 1 then, the corresponding pixel is made bright on the screen and if it is zero then no brightness appears i.e., 0→off; 1 → ON so the image obtained on the screen is discrete.

Different kinds of memory have been used in frame buffers: The earliest type of frame buffers used drums and disks with rotational frequency compatible to the rate of refresh. Such frame buffers were called **rotating-memory frame buffers**. But the relatively lower costs of integrated-circuit shift registers saw the rotating-memory frame buffer being replaced by the **shift-register frame buffers**.

A frame buffer can be constructed with a number of shift registers, each representing one column of pixels on the screen. Each shift register contributes one bit per horizontal scan line. However, changing a given spot on the screen is not very easy with shift registers. So they are not suitable for interactive applications.

Modern frame buffers use random-scan integrated circuits (discussed earlier) where the pixel intensities are represented by 1,2,4,8,16 or 24 bits. Encoding text and simple images does not require more than say, 8 bit per pixel. But to produce a good quality coloured image more than 8 bits, something like 24 bits, are required.

One of the best methods to encode coloured pictures involves the use of a colour map. The pixel values in the frame buffer are treated as addresses of a look-up-table, which has entries for every pixel's red, green and blue components. The entry value is used to control the intensity or colour on the CRT; each of the colour components can be defined to high precision providing accurate control over the colours displayed.

Another type of frame buffer is the **multiple-plane frame buffer,** where the frame buffer can be treated as consisting of several frames or planes, each containing information (intensity and/or colour) values of a separate image. An 8-bit per pixel frame buffer can be made to represent a single image with 8-bits of intensity precision or it can represent tow images each of 4-bit intensity precision or eight black and white images with 1-bit intensity precision each. A variety of image mixing can be done. For example, in animation systems, several moving objects can be displayed as separate planes.

Note:

1) In a frame buffer, information storage starts from top left corner and goes till the bottom right corner.
2) Using this type of buffer we can draw curves too.
3) So in order to draw live images of objects of day-to-day life, enormous picture information is required and this is the limitation.
4) How to vary intensity of a point (bright point) in Raster scan display device)

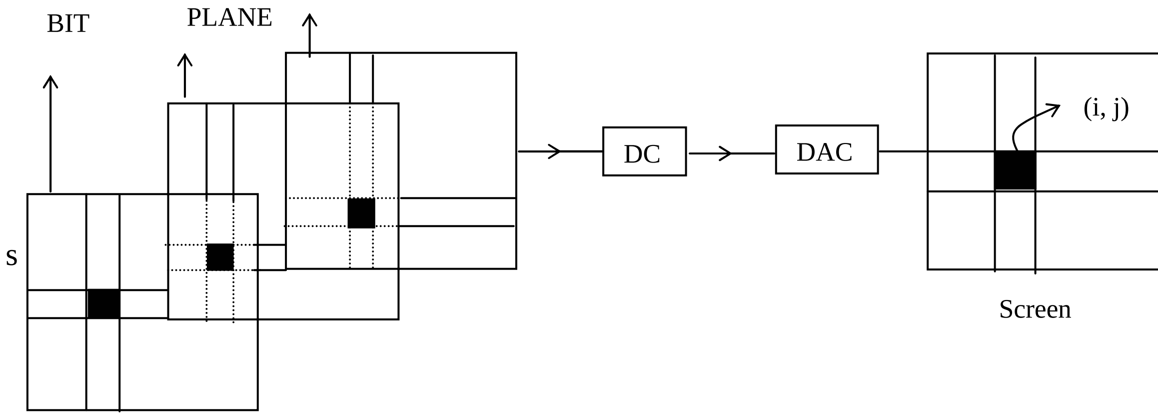


Figure 15: Frame buffer: Intensity Variation of a pixel

Picture Information

Here, the picture information is stored in the form of bit plans (on each bit plane full information of picture is stored) and for brightest intensity 3 bit plane (say for simplicity) should have 1 as respective information in the frame buffer, if it is zero then, the intensity will be the least; some of the intensity combination are discussed below:

bit plane			
A	B	C	
0	0	0	→ min. intensity of a point
0	0	1	
0	1	0	→ value of a pixel in 2nd bit plane
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	→ max intensity of a point

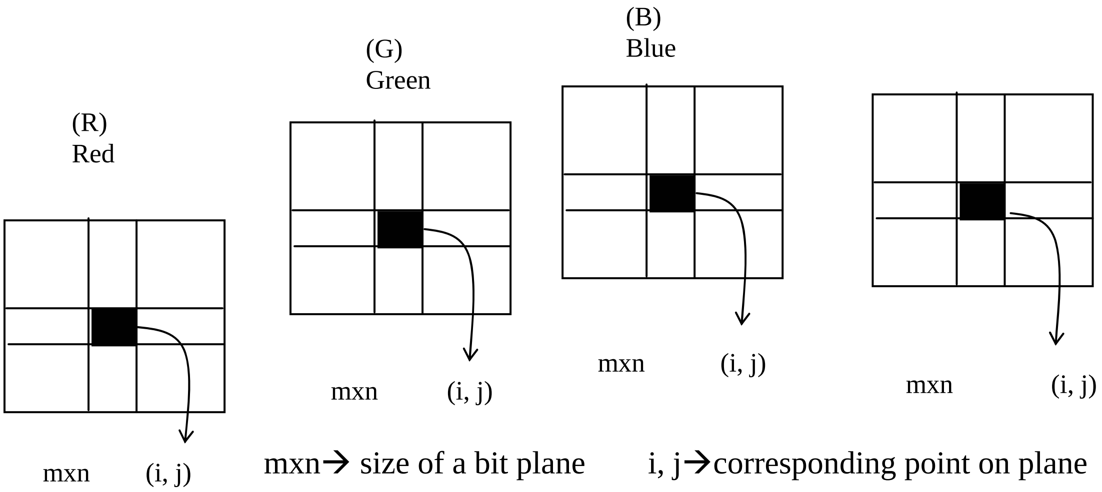
Maximum intensity of a pixel implies that the value for that point on each bit plane is 1 which generates maximum intensity (to have a bit low intensity any one of the bit plane is given information 0 for that point and so on):

If picture information is stored in 2 bit planes then possibilities are:

0 0 $\longrightarrow$ min. intensity of a point
0 1 $\longrightarrow$ medium intensity of a point
1 0 $\longrightarrow$ medium intensity of a point
1 1 $\longrightarrow$ max intensity of a point

For corresponding pixel on screen:

- each information digit is 0 or 1 for respective bit plane in continuation,
- each digit constitutes the information for a point in the respective bit plane,
- for 2 bit planes we have 4 levels, similarly, 3 bit planes we have 8 levels i.e., for n bit planes we have 2^n levels.
  $\Rightarrow$ for n bit plane 2^n amount of information is needed.
- By adopting this method of picture information storage, no doubt, we can vary the intensity of adopting but more memory consumption occurs because there exists more bit planes.
- For controlling the intensity of the colours, we need a minimum of 8 bit planes i.e., picture information has to have 8 digits (0, 1) further 2^8 combinations occur.
- For colours case we need in general 3 electron guns of 3 colours (red, green and blue) for picture display with varying colours.



mxn→ size of a bit plane   i, j→corresponding point on plane

Picture information

Figure 16: Frame Buffer: Colour Variation of a Pixel

As in the figure above we have 3 bit planes so we have 3 digit numbers. If information in each plane (R, G, B) is zero i.e., (0, 0, 0) then there is no display. Other situations are listed below:

	R	G	B	
So,	0	0	0	no display
	0	0	1	Blue display
	0	1	0	Green display
	0	1	1	Green-blue mix display and so on.

Similarly, for more colours we should have more bit planes and hence more numbers of digits signify more colour combinations.

Similarly we can control the intensity of colours

We have more bit planes for each colour say 3 bit planes for R, 3 for G and 3 for B (each bit plane of size mxn) so there exist a digit number and by respective 1s and 0s we can control colour intensity too. Here, the amount of information needed is 2^9 or amount of information needed is 2^3, 2^3, 2^3 for each R, G, B. Thus we can generate light red, light green or combination of light red, dark green, medium blue and so on.

Example 1: What is the number of memory bits required for 3 bit –plane frame buffer for a 512 x 512 raster.

Solution: Total memory bits required are 3 x 512 x 512 = 786,432

Example 2: What is the refresh rate in a 512 x 512 raster if pixels are accessed at the rate of 200 nanoseconds.

Solution. For individual access of pixels rate is 200×10^{-9} seconds, for 512x512 pixels 0.0524 seconds required.

Refresh rate per second is 1/0.0524 =19 frames/seconds.

Plasma Panel

It is an inherent memory device. Images can be written onto the surface point by point and they remain stable, without flicker, for a long time after being intensified. An inert mixture of noble gases (neon and xenon) gas is filled and sealed between two glass sheets with fine-mesh gold-wire electrodes attached to their inner faces. The particles of the gas behave in a bi-stable manner, that is stable at two levels (on/off). When voltage is applied across the electrodes the gas molecules get ionised and are activated giving rise to a glow.

The fine mesh of electrodes makes up thousands of addressable cells. A definite picture is generated when gas particles in the corresponding cells are excited by the application of the appropriate voltages. The ionised gas molecules in the cells excited by the applied voltages glow, making the picture visible until the current is turned off. This gives a steady image but the resolution is poor (60 dots per inch), and the hardware is much more complex (hence costlier) than raster scan.The plasma display panel is less bulky than the CRT but also vary the cost of construction is very high. Addressing of cells and wiring is complex.

Advantage

- Slim design (Wall mountable)
- Larger than LCD screens

Disadvantage

- Expensive, although cheaper than LCDs in larger sizes.
- Is subject to screen burn-in, but modern panels have a manufacturer rated lifespan of 50,000 or more hours.
- First 2000 hours is its brightest point. Every hour thereafter, the display gradually dims.
- At higher elevations, usually 6000 ft or higher, they exhibit noticeable humming.

LCD

Liquid Crystal Display is a type of display used in digital watches and many portable computers. These work with polarised ambient (outside source) light consisting of liquid crystal (a material which polarises light when a voltage is applied to it), with a conductive coating for the voltage application, set between two transparent glass or plastic plates and a polarised film on one side which will show the excited portions of the liquid crystal as dark dots or lines. (The seven-segment display of most digital watches is an example of LCD by lines). This technology is now applied to Data Projectors to project computer generated or stored images directly on to big screens in auditoriums.

LCD displays utilise two sheets of polarising material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light.

Monochrome LCD images usually appear as blue or dark gray images on top of a grayish-white background. Colour LCD displays use two basic techniques for producing colour: *Passive matrix* is the less expensive of the two technologies. The other technology, called *Thin Film Transistor* (TFT) or *active-matrix*, produces colour images that are as sharp as traditional CRT displays, but the technology is expensive. Recent passive-matrix displays using new CSTN and DSTN technologies produce sharp colours rivaling active-matrix displays. Most LCD screens used in notebook computers are backlit, or transmissive, to make them easier to read.

☞ Check Your Progress 5

1) What are Refreshing display devices? What are their limitations?

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2) Differentiate between Random and Raster Scan display devices.

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1.5 SUMMARY

In this unit, we have discussed the conceptual meaning of computer graphics, with its application in various fields right from presentation graphics to animation and games. We have also discussed the variety of software and their respective file formats used in various applications of computer graphics. In the end, we have discussed the working of various input and output devices. Finally, the discussion on display devices was done with coverage to Refreshing Display Devices, and Plasma Panels, and LCD Display Devices.

1.6 SOLUTIONS/ANSWERS

Check Your Progress 1

1) A few of the various applications areas which are influenced by Computer graphics are:

    - Presentation Graphics
    - Painting Drawing
    - Photo Editing
    - Scientific Visualisation
    - Image Processing
    - Digital Art
    - Education, Training, Entertainment and CAD
    - Simulation
    - Animation and games.

2) GIF, JPG, BMP, PSD, TIFF, PNG etc.

3) TIFF or PNG: TIFF has been around longer than PNG, which was originally designed to replace GIF on the Web. PowerPoint works well with both of these files when creating transparent backgrounds but generally PNG creates smaller file sizes with no loss of quality.

4)

Drawing	***Painting***
Drawing is a software application means using tools that create "objects," such as squares, circles, lines or text, which the program treats as discrete units. If you draw a square in PowerPoint, for example, you can click anywhere on the square and move it around or resize it. It's an object, just like typing the letter "e" in a word processor, i.e., a drawing program allows a user to position standard shape (also called symbols, templates, or objects) which can be edited by translation, rotations and scaling operations on these shapes.	***Painting*** functions, on the other hand, don't create objects. If you look at a computer screen, you'll see that it's made up of millions of tiny dots called pixels. You'll see the same thing in a simpler form if you look at the colour comics in the Sunday newspaper—lots of dots of different colour ink that form a picture. Unlike a drawing function, a paint function changes the colour of individual pixels based on the tools you choose. In a photograph of a person's face, for example, the colours change gradually because of light, shadow and complexion. You need a paint function to create this kind of effect; there's no object that you can select or move the way you can with the drawn square, i.e., a painting program allows the user to paint arbitrary swaths using a brush various size, shape, colour and pattern. More painting programs allows placement of such predefined shapes as rectangles, polygon and canvas. Any part of the canvas can be edited at the pixel level.

The reason why the differences are important is that, as noted earlier, many different kinds of programs offer different kinds of graphics features at different levels of sophistication, but they tend to specialise in one or the other.

5) To Create posters, brochures, business cards, stationary, coffee cup mug design, cereal boxes, candy wrappers, orange juice gallon jugs, cups, or anything else you see in print. Most designers will use vectorised programs to make these things come to life. Vectors are wonderful because they print extremely well, and you can scale them up to make them large, or scale them down to make them small, and there is no distortion. **Adobe Illustrator is the King of Vector Programs**. In Adobe Illustrator, you can create a 12 foot, by 12 foot document.

6) If you are going to make a magazine, newspaper, book or maybe a multipage menu for a restaurant. In that case, we need a page layout program. The well known softwares in page layout are:

   (a) Quark Express
   (b) Page Maker (Adobe)
   (c) Indesign (Adobe)
   (d) Publisher (MicroSoft)

7) No, other example of softwares are Apple's Keynote, Openoffice's (Star Office-by Sun microsystems), Impress, Microsoft Powerpoint and (for multimedia presentations, incorporating moving pictures, and sounds) Macromedia Director. Custom graphics can also be created in other programs such as Adobe Photoshop or Adobe Illustrator.

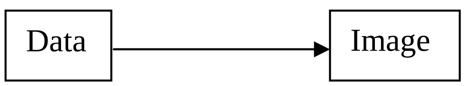
Check Your Progress 2

1) Photo-editing stream involves programs, which are not just paint programs—but they include many sophisticated functions for altering images and for controlling aspects of the image, like light and colour balance. Some of the professionally used software for photo editing are PhotoShop (Adobe), FireWorks (Macro Media), Corel (owned by Corel) etc.

2) Scientific visualisation involves interdisciplinary research into robust and effective computer science and visualisation tools for solving problems in biology, aeronautics, medical imaging, and other disciplines. The profound impact of scientific computing upon virtually every area of science and engineering has been well established. Some examples of the software used in this field are:

   Matlab (by The Math Works Inc.)
   Mathematica or Maple (graphical computer algebra system)
   Stella (models dynamic systems)
   IDL (Interactive Data Systems) by Research System Inc.
   AVS (Application Visualisation System) by Advance visual System Inc.

3) Image Processing means *image in* → processed *image out*
   Images are the final product of most processes in computer graphics. The ISO (International Standards Organisation) defines computer graphics as the sum total of methods and techniques for concerning data for a graphics device by a computer. It summarise and computer graphics as converting data into images, which is known as visualisation.



   Some of the categories of image processing software with their respective examples and features are listed below:

   (a) ***Graphics Image Processing:*** Commonly used software example is: Photoshop.
   (b) ***Geographic Information Systems (GIS):*** Commonly used software example is: ArcMap.
   (c) ***Remote Sensing Packages:*** Commonly used software example is: ERDAS.
   (d) ***Numerical Analysis Packages:*** Commonly used software example is: MatLab.

(e) ***Web-based Services:*** Commonly used software example is: Protected Area Archive.

4) No. While true-scale, structurally valid drawings are the reason for CAD's existence, its use is as diverse as our customer's imaginations.

   (a) Page layout, web graphics (when scaling and relationships are important to an image, making the image in CAD and exporting it as a bitmap for touchup and conversion can be very productive).
   (b) Visually accessed databases (imagine a map with details where you can zoom into an area and edit textual information "in place" and you can then see what other items of interest are "in the neighbourhood" – our program's ability to work very rapidly with large drawings is a real plus here).
   (c) Sign layout, laser-cutting patterns for garment factories, schematic design (where CAD's symbol library capabilities come in handy), and printed-circuit board layout (This was the application that our first CAD program, created in 1977).

5) The DWG file format is a CAD vector format developed by Autodesk and created by their AutoCAD application. DXF is also a CAD vector format. It is designed to allow the exchange of vector information between different CAD applications. Most CAD applications can save to and read from DXF format.

   When CAD drawings are sent to printers the format commonly used is HPGL. HPGL files typically have the extension .plt.

   The HPGL file format is a vector format developed by Hewlett Packard for driving plotters. The file extensions used include .plt, .hpg, .hp2, .pl2 and sometimes .prn. However, the use of the .prn extension is not an absolute indicator that the file contains an HPGL code. They are often referred to as 'plot files'. Trix Systems offers several options for handling HPGL and the later HPGL2 file formats.

Check Your Progress 3

1) Computer simulation is the discipline of designing a model of an actual or theoretical physical system, executing the model on a digital computer, and analysing the execution output. Simulation embodies the principle of "learning by doing" – to learn about the system we must first build a model of some sort and then operate the model. Simulation is often essential in the following cases:

- the model is very complex with many variables and interacting components;
- the underlying variables relationships are nonlinear;
- the model contains random variates;
- the model output is to be visual as in a 3D computer animation.

The Advantage of Simulation is that – even for easily solvable linear systems – a uniform model execution technique can be used to solve a large variety of systems without resorting to a "bag of tricks" where one must choose special-purpose and sometimes arcane solution methods to avoid simulation. Another important aspect of the simulation technique is that one builds a simulation model to replicate the actual system. When one uses the closed-form approach, the model is sometimes twisted to suit the closed-form nature of the solution method rather than to accurately represent the physical system. A harmonious compromise is to tackle system modeling with a hybrid approach using both closed-form methods and simulation. For example, we might begin to model a system with closed-form analysis and then proceed later with a simulation. This evolutionary procedure is often very effective.

Pitfalls in Computer Simulation

Although generally ignored in computer simulations, in strict logic the rules governing floating point arithmetic still apply. For example, the probabilistic risk analysis of factors determining the success of an oilfield exploration program involves combining samples from a variety of statistical distributions using the MonteCarlo methods. These include normal, lognormal, uniform and the triangular distributions. However, a sample from a distribution cannot sustain more significant figures than were present in data or estimates that established those distributions. Thus, abiding by the rules of significant arithmatic, no result of a simulation can sustain more significant figures than were present in the input parameter with the least number of significant figures. If, for instance the net/gross ratio of oil-bearing strata is known to only one significant figure, then the result of the simulation cannot be more precise than one significant figure, although it may be presented as having three or four significant figures.

2) Animation is a time based phenomenon for imparting visual changes in any scene according to any time sequence, the visual changes could be incorporated through translation of object, scaling of object, or change in colour, transparency, surface texture etc., whereas Graphics does not contain the dimension of time.

Graphics + Dimension of Time = Animation

Check Your Progress 4

1) A graphic tablet is a drawing tablet used for sketching new images or tracing old ones. Or we can say that a graphics tablet is a computer input device that allows one to hand-draw images and graphics, similar to the way one draws images with a pencil or paper. Or Graphics tablet is a computer peripheral device that allows one to hand images directly into a computer, generally through an imaging program.

   Difference between pen and puck: Objects are drawn with a pen (or stylus) or puck, but are traced with the puck only.

2) Touch panels allow displayed objects or screen positions to be selected with the touch of the finger, also known as Touch Sensitive Screens (TSS). Four types of touch panels commonly in use, are Electrical, Electro-Mechanical, Optical, Acoustic touch panels.

3) The differences between printers and plotters:

   (a) Plotters print their output by moving a pen across the surface of piece of a paper. This means that plotters are restricted to line art, rather than raster graphics as with other printers. They can draw complex line art, including text, but do so very slowly because of mechanical movement of pen.

   (b) Another difference between plotter and printer is that the printer is aimed primarily at printing text. Thus, the printer is enough to generate a page of output, but this is not the case with the line art on a plotter.

4) Film recorder is a graphical output devices for transferring digital images to photographic films.

Check Your Progress 5

1) Refreshing display devices are those display devices in which the picture continuously refreshes. The general refresh rate is 40 to 60 times per second example CRT. There are two kinds of refreshing display devices, namely the random scan and raster scan, the limitation is that these devices are not competent to provide smooth and good quality images.

2) In Random Scan system the Display buffer stores the picture information, further the device is capable of producing pictures made up of lines but not of curves. Thus, it is also known as “Vector display device or Line display device or Calligraphic display device.

   In Raster Scan system the Frame buffer stores the picture information which is the bit plane (with m rows and n columns) because of this type of storage the system is capable of producing realistic images, but the limitation is that the line segments may not appear to be smooth.