Basics of Computer Graphics

Computer Graphics is about animation (films)

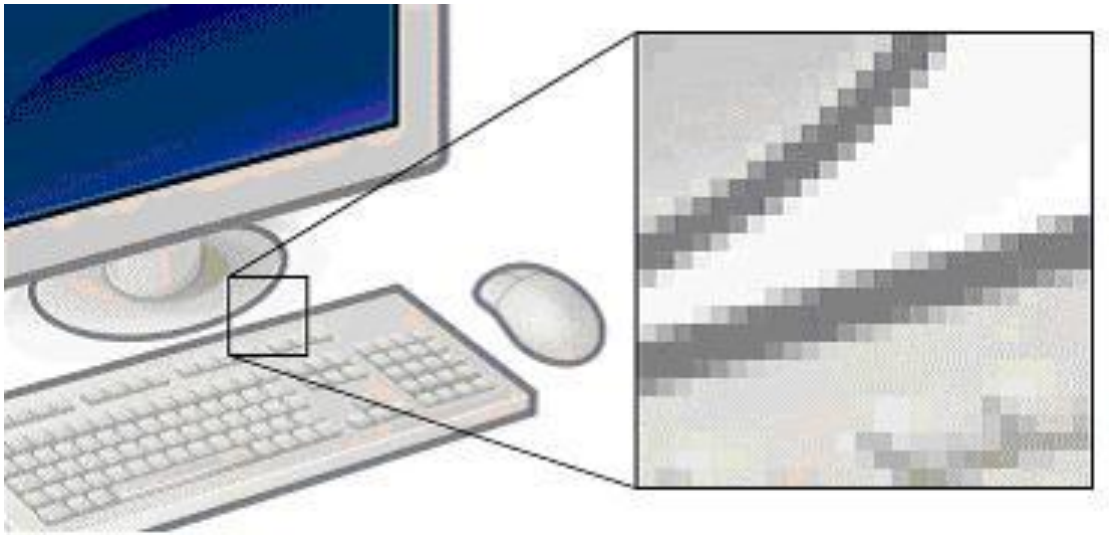
Computer graphics

- It is the creation and manipulation of graphic images by means of a computer.
  - Computer graphics started as a technique to **enhance** the display of information generated by a computer.
  - This ability to interpret and represent numerical data in pictures has significantly **increased** the **computer's ability** to present information to the user in a clear and understandable form.
  - Large amount of data are rapidly converted into bar charts, pie charts, and graphs.

Pixel (picture element)

a **pixel** is the smallest piece of information in an image.

- Pixels are normally arranged in a regular **2D grid**, and are often represented using **dots** or **squares**.



Pixel (picture element)

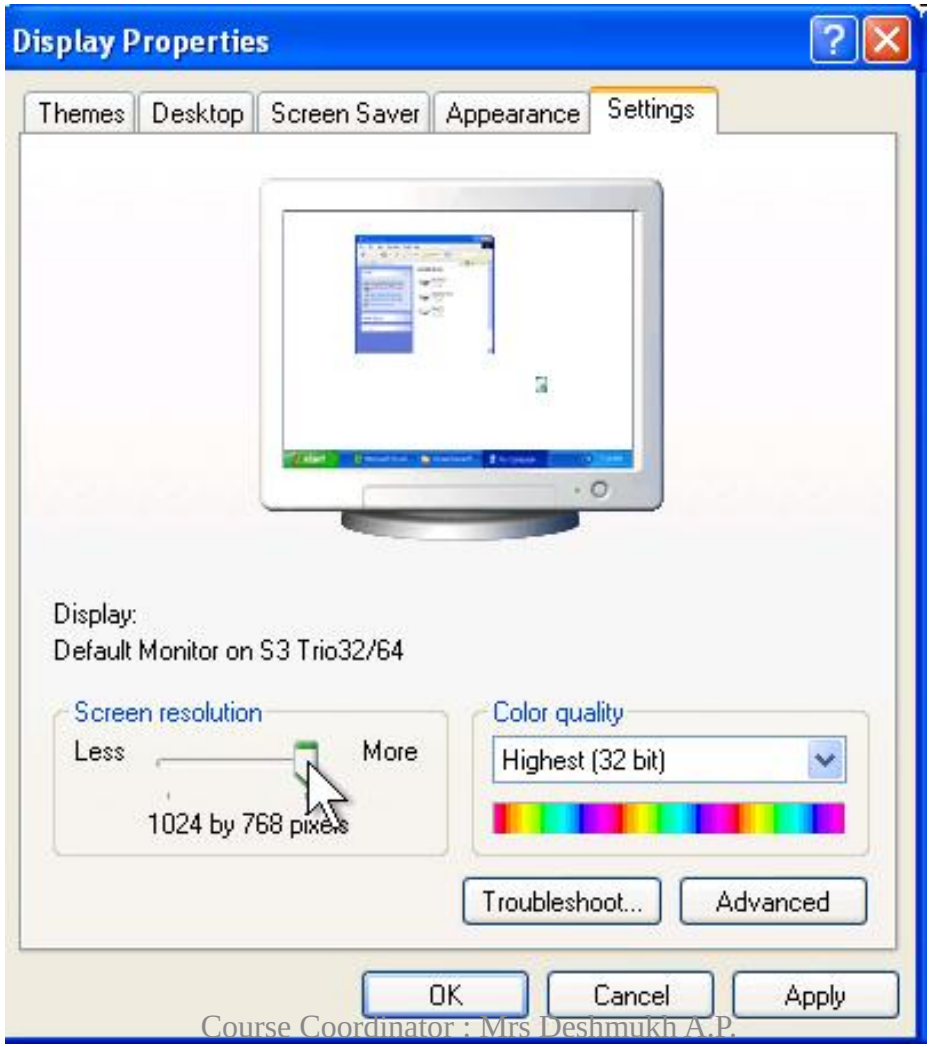
- Each pixel is a **sample** of an original image, where more samples typically provide a more accurate representation of the original.
- The **intensity** of each pixel is variable; in color systems, each pixel has typically three or four components such as red, green, and blue, or cyan, magenta, yellow, and black.

Resolution

- Resolution is the number of rows that appear from top to bottom of a screen and in turn the number of pixels or pixel elements that appear from left to right on each scan line.
- Based on this **resolution only the effect of picture appears on screen**.
- In other words greater the resolution greater will be the clarity of picture. That is resolution value is directly proportional to clarity of picture.

- Actual resolution is determined by the video controller.
  - Most monitors can operate at several different resolutions. They are
  - 640 X 480
  - 800 X 600
  - 1024 X 768
  - 1152 X 864
  - 1280 X 1024
- As the resolution increases, image on the screen gets smaller.

Resolution Settings



1) Image **Resolution**: It refers to pixel spacing. In normal **PC** monitor it ranges between 25 to 80 pixels per inch.

2) Screen **Resolution**: It is the number of distinct pixels in each dimension that can be displayed.

For example, a computer with a display resolution of 1280 x 768 will produce a maximum of 98,3040 pixels on a display screen. Each pixel has a unique logical address, a size of eight bits or more and, in most high-end display devices, the ability to project millions of different colors.

Text mode

- Text mode is a personal computer display setting that divides the display screen into **25 rows and 80 columns** in order to display text without images.

- In text mode, each box can contain one character. Text mode contrasts with graphics mode, which features an array of pixels instead of text boxes.

- Text mode is also known as **character mode or alphanumeric mode**.

Graphics mode

- **Graphics mode** is a computer display mode that generates image using pixels.

- Today, most users operate their computer in a graphics mode opposed to a text mode or command line environment.

initgraph(&gd,&gm,"c:\\turboc3\\bgi");

Graphics mode graphics Function

- **GRAPHICS.H** ,this file contains definitions and explanation of all the graphic functions and constants While GRAPHICS.LIB file contains standard graphic functions.
- **InitGraph:**
- Initializes the graphics system.

Declaration:

void initgraph(int *graphdriver, int *graphmode, char *pathtodriver);

eg: void initgraph(&gd,&gm,”path of bgi file”);

Initgraph Arguments:

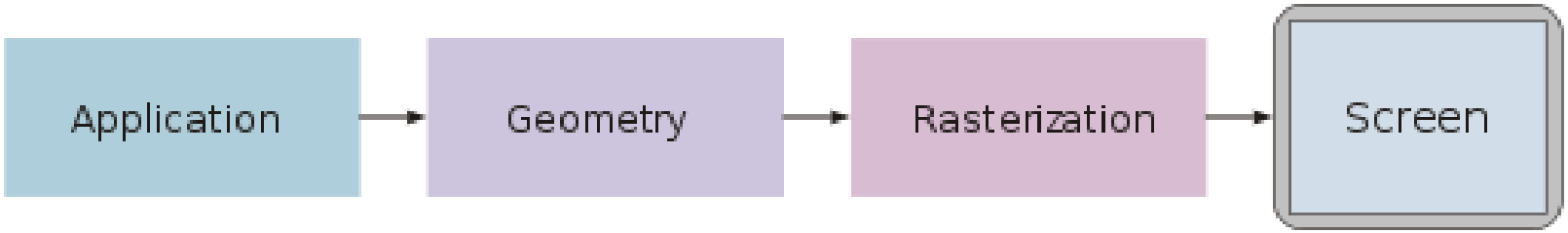
- *graphdriver: Integer that specifies the graphics driver to be used.

- *graphmode : Integer that specifies the initial graphics mode. If *graphdriver = DETECT, initgraph sets *graphmode to the highest resolution available for the detected driver.

- pathtodriver : Specifies the directory path where initgraph looks for graphics drivers (*.BGI) first.

A graphics pipeline

- A graphics pipeline can be divided into three main parts: Application, Geometry and Rasterization.



Application

- The application step is executed by the software on the main processor (CPU), it cannot be divided into individual steps, which are executed in a pipelined manner.

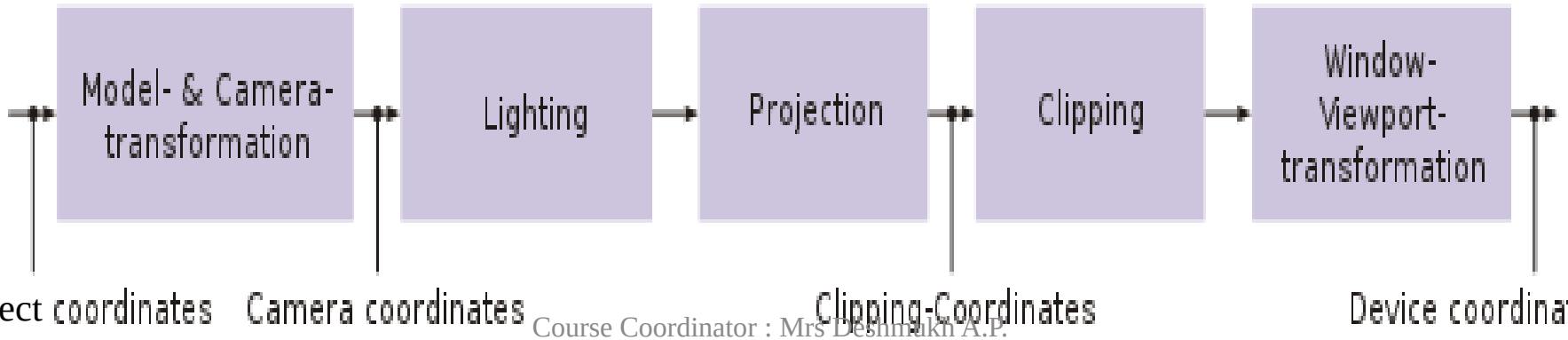
- In the application step, changes are made to the scene as required, for example, by user interaction by means of input devices or during an animation.

- The new scene with all its primitives, usually triangles, lines and points, is then passed on to the next step in the pipeline.

Geometry

- The geometry step is responsible for the majority of the operations with polygons and their vertices , can be divided into the following five tasks.

- It depends on the particular implementation of how these tasks are organized as actual parallel pipeline steps.



Rasterization

- **Rasterization** is the task of taking an image described in a vector graphics format (shapes) and converting it into a raster image (pixels or dots) for output on a video display or printer, or for storage in a bitmap file format. It refers to both rasterization of models and 2D rendering primitives such as polygons, line segments, etc.

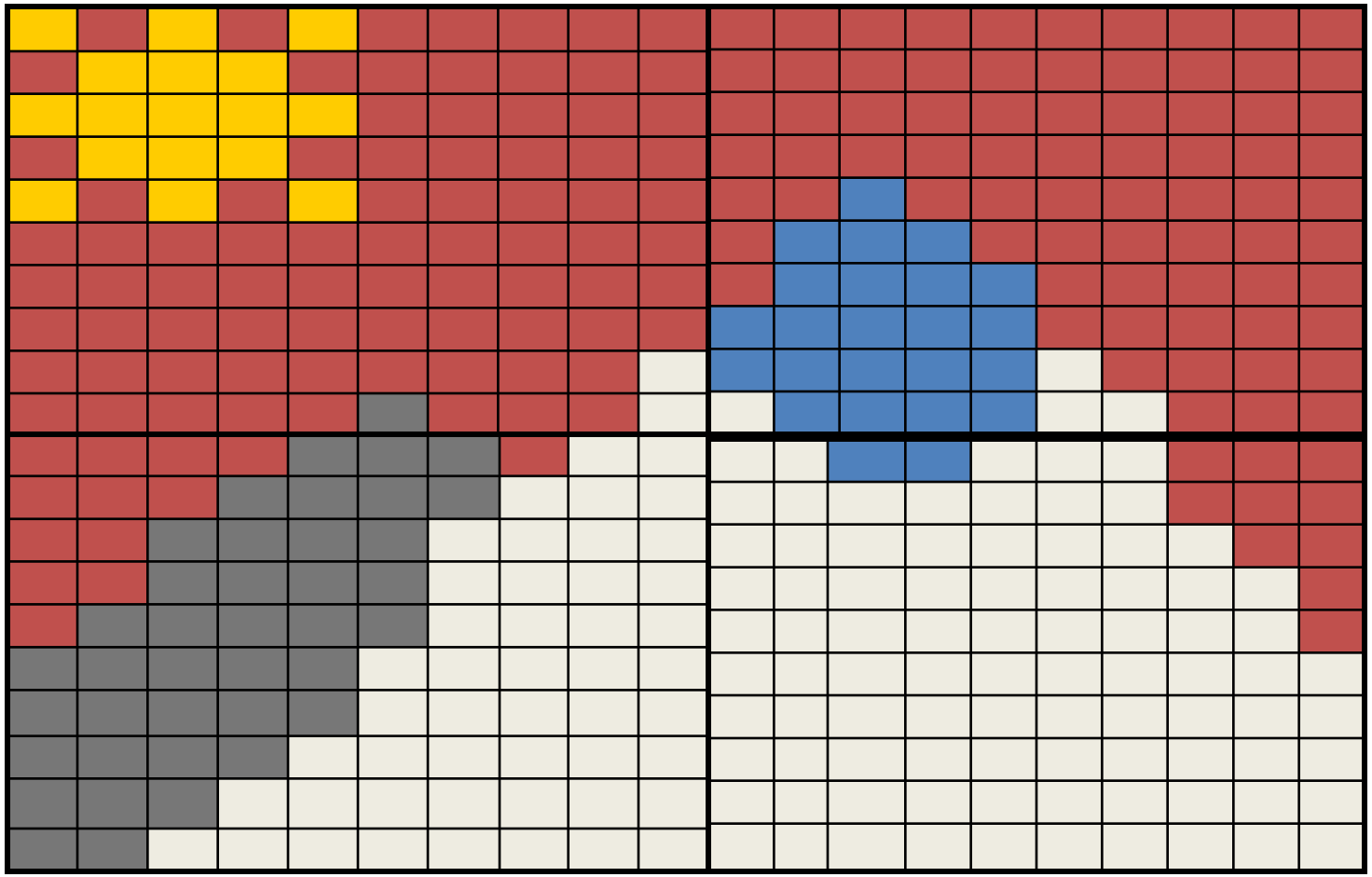
Bitmapped Graphics

- There are two basic types of graphics:
  - *Bitmapped* and
  - *Vector*
- Bitmapped graphics are much more common
- Often they are called raster graphics
- When you create a bitmapped graphic you are basically creating a bunch of colored dots

Bitmapped Graphics, cont.

- The bitmapped graphic is stored as an array of dots, or pixels
- Each pixel gets assigned a specific color
- The more pixels you have, the more detailed the image can be
  - Imagine only have one pixel, all you get is a dot
- Some common bitmap graphics programs are:
  - Photoshop
  - Paint Shop Pro
  - GIMP
  - Photo-Paint
  - Graphic Converter
- These are *paint programs*

Exaggerated Example of a Bitmap Image



Vector Graphics

- The second major type of computer graphics
- Vector graphics are created and manipulated using *drawing programs* (as opposed to paint programs for bitmapped graphics)
- Instead of using pixels to describe the image, it describes the image using shapes
  - Circles
  - Lines
  - Curves
- Also has to store the color of these shapes
- A verbal example would be something like:
  - “A yellow circle with a center here and a radius of x, a purple line from here to here”

Vector Graphics, cont.

- The programs used with vector graphics are drawing programs
- Some of these programs include:
  - Corel Draw
  - Adobe Illustrator
  - Acrobat
- Most of these programs allow the use of bitmapped images as part of a vector image
  - Does not make them paint programs
  - Bitmaps are a type of object (like a circle) that can be inserted into a vector image

Bitmap vs. Vector Images

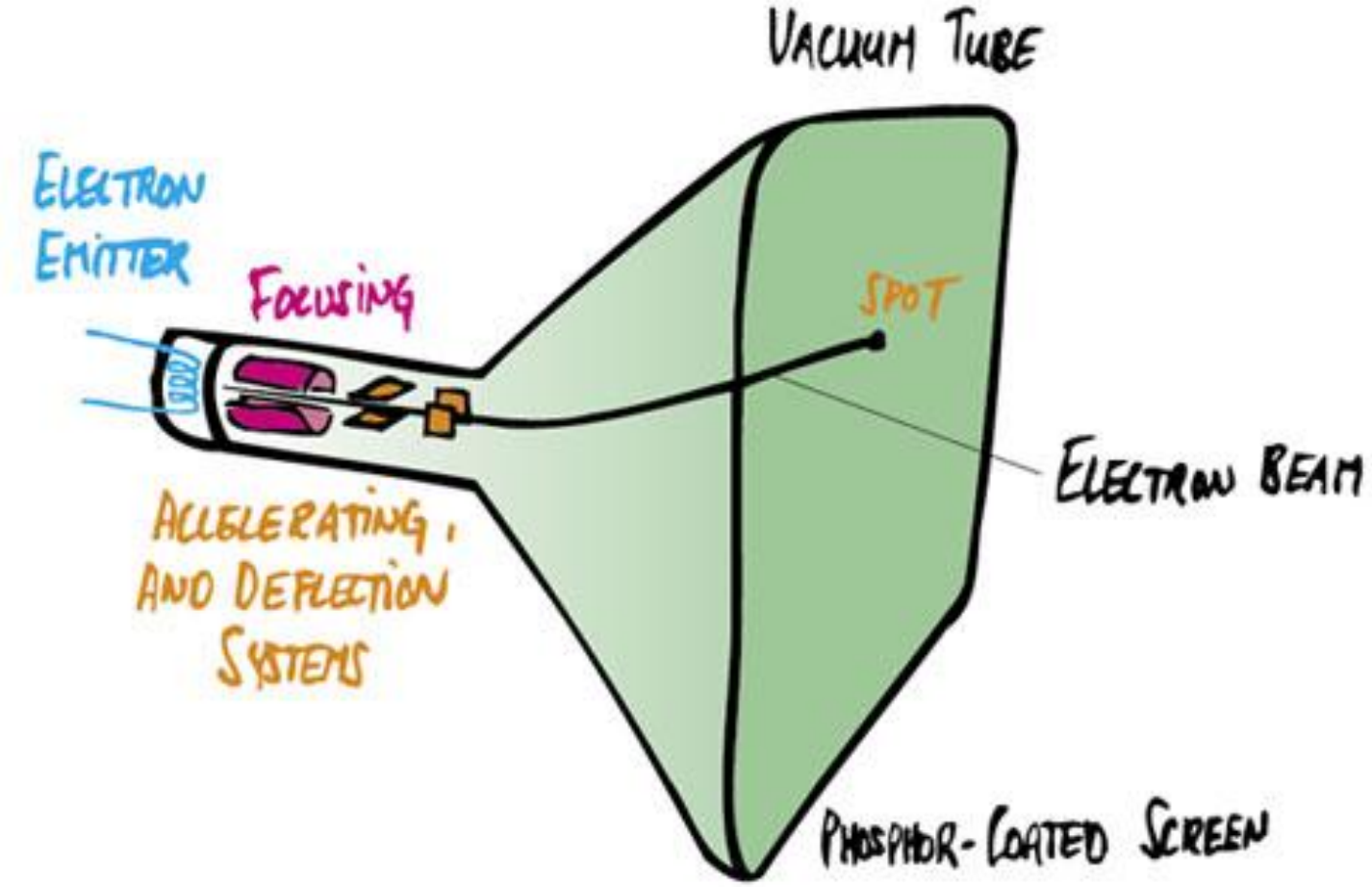
- Bitmap and vector images are obviously different
- Both have strengths and weaknesses
- They don’t manipulate images in the same way
- They don’t store images in the same way
- The images are edited differently

Applications of Computer Graphics

- **Computer graphics user interfaces** (GUIs) – A graphic, mouse-oriented paradigm which allows the user to interact with a computer.
- **Business presentation graphics** – "A picture is worth a thousand words".
- **Cartography** – Drawing maps.
- **Weather Maps** – Real-time mapping, symbolic representations.
- **Satellite Imaging** – Geodesic images.

- **Photo Enhancement** – Sharpening blurred photos.
- **Medical imaging** – MRIs, CAT scans, etc. - Non-invasive internal examination.
- **Engineering drawings** – mechanical, electrical, civil, etc. - Replacing the blueprints of the past.
- **Architecture** – Construction plans, exterior sketches - replacing the blueprints and hand drawings of the past.
- **Art** – Computers provide a new medium for artists.
- **Entertainment** – Movies and games.
- **Simulation and modeling** – Replacing physical modeling and enactments

Display Technologies

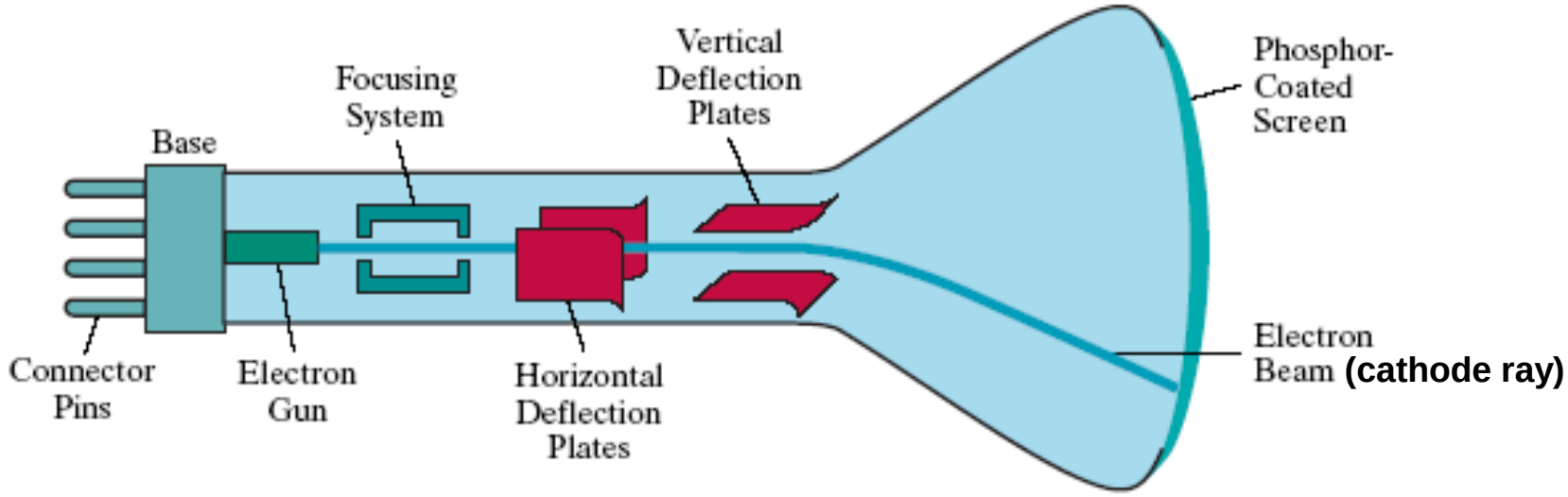


Type of Display Device

- Type of CRT
  - Random-Scan Displays
  - Raster-Scan-Displays
- Flat-Panel Displays
  - Emissive displays
  - Nonemissive displays

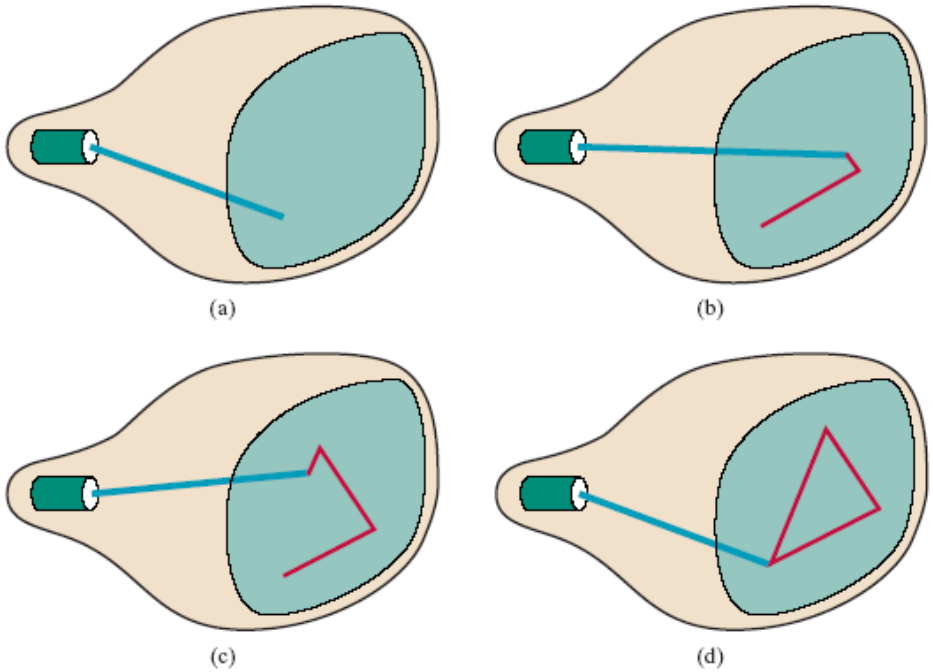
Video Display Devices

- Cathode-Ray Tube(CRT)



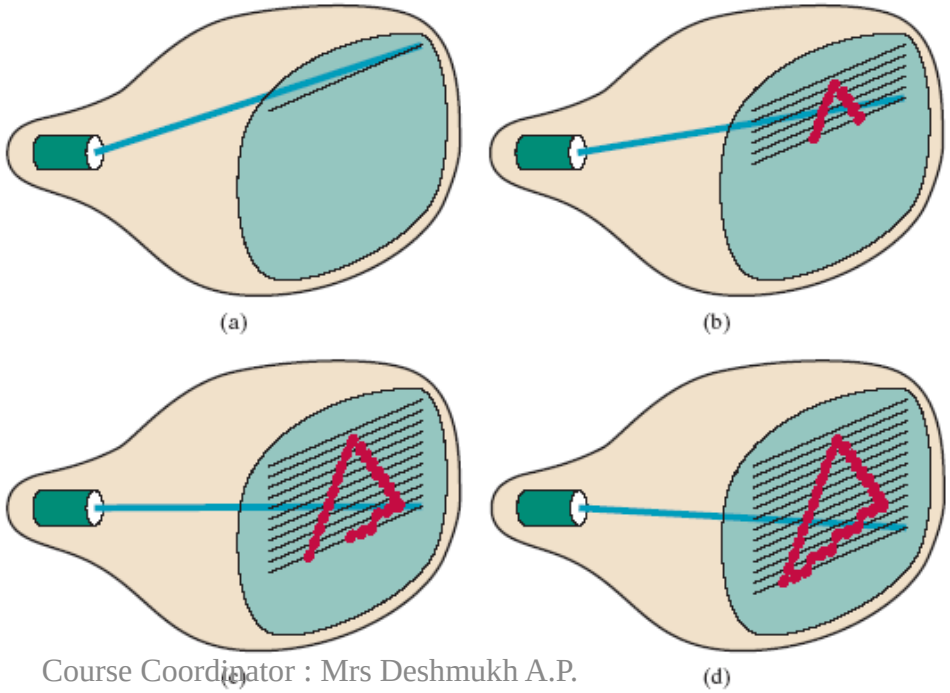
Random-Scan Display

- Vector Display (calligraphic display)
- stored as a set of line-drawing commands in an area of memory (refresh display file, display list, display program)
- draw a picture one line at a time



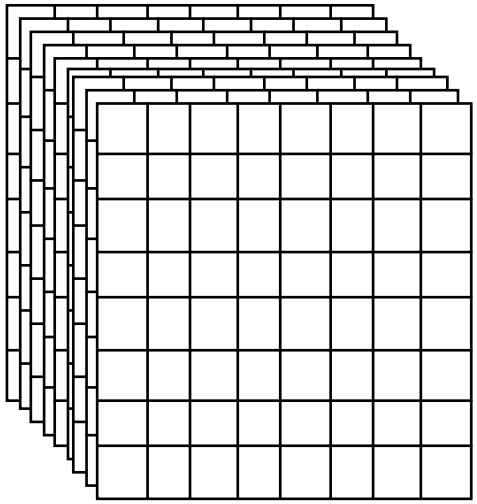
Raster-Scan Displays (1/3)

- Point plotting device : ***pixel*** or *pel* (Picture Element)
- picture info. for all the screen points is stored in separate Memory called ***Frame buffer*** *(Refresh Buffer)*
- one row at a time (***scan line***) from top to bottom



Frame Buffer

- A frame buffer is characterized by size, x, y, and pixel depth.
- the **resolution** of a frame buffer is the number of pixels in the display. e.g. 1024x1024 pixels.
- Bit Planes or Bit Depth is the number of bits corresponding to each pixel. This determines



Bilevel or **monochrome** displays have 1 bit/pixel

8bits/pixel -> 256 simultaneous colors

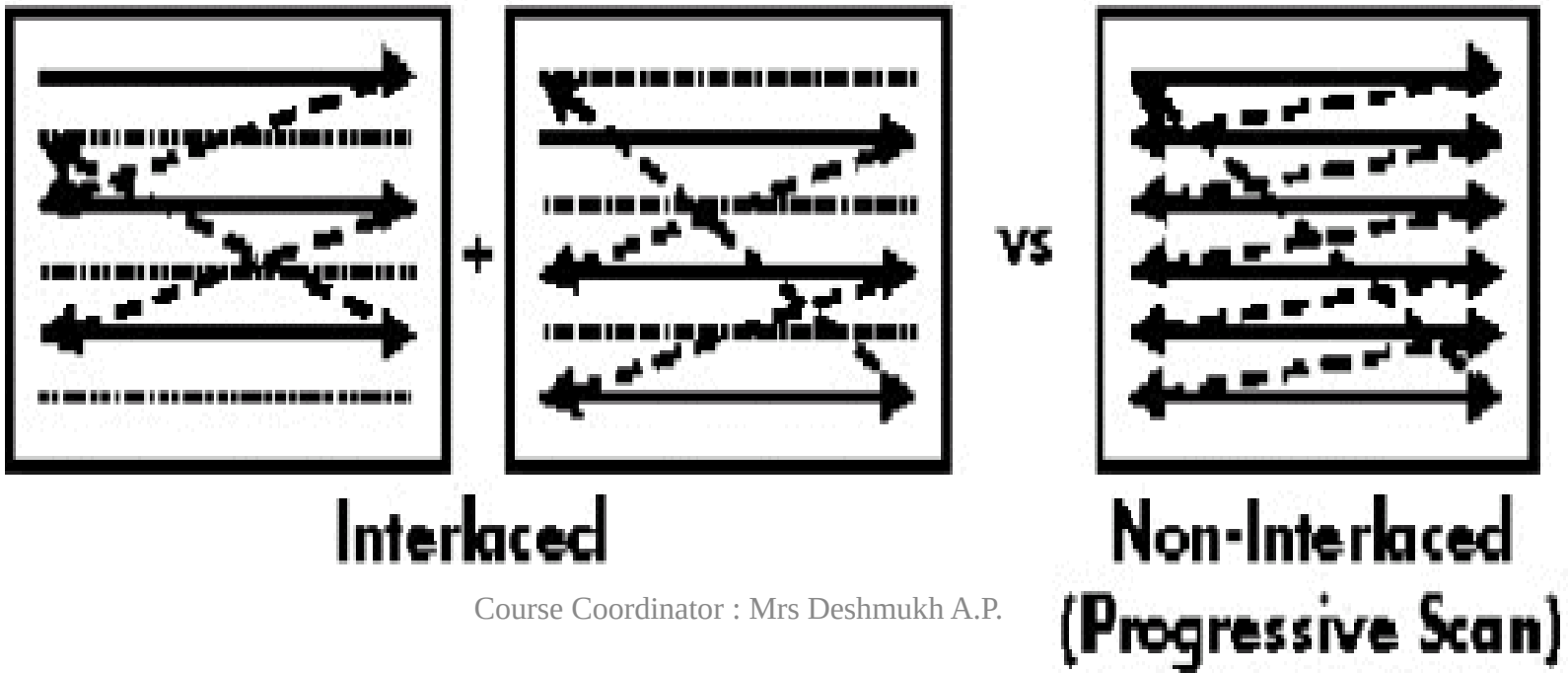
24bits/pixel -> 16 million simultaneous colors

Raster-Scan Displays (2/3)

- Frame buffer
  - Depth of the buffer area, Number of bit planes
  - Bitmap: one bit per pixel
  - Pixmap: multiple bits per pixel
- Refresh rate
  - Above about 24 frame per second
  - Unit of refresh rates ➔ Hz
    - Ex) 60 frames per second (60Hz)

Raster-Scan Displays (3/3)

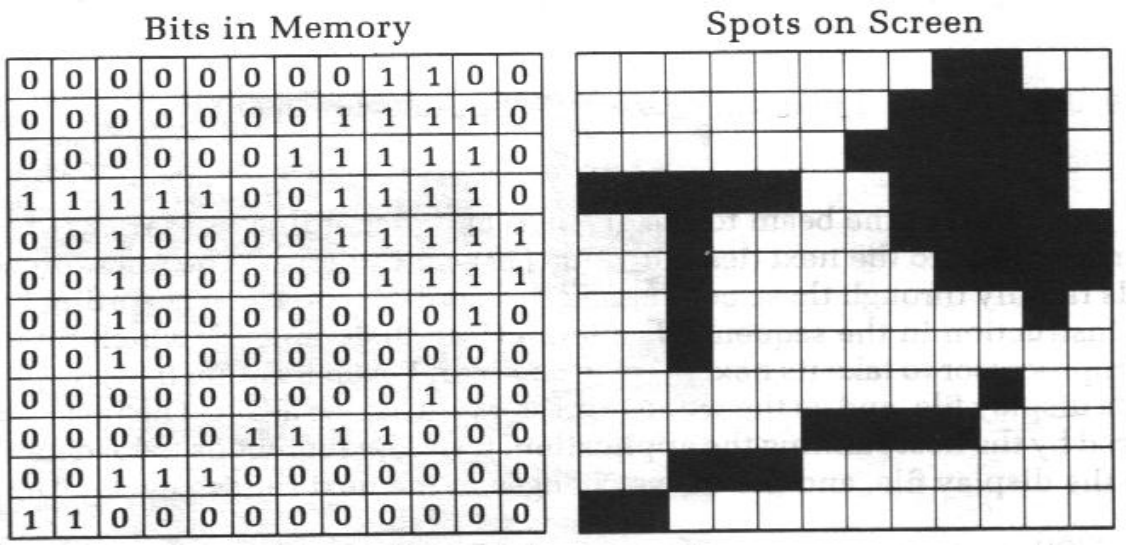
- Picture definition is stored in memory area called the **Refresh Buffer** or **Frame Buffer**.
- This memory area holds the set of intensity values for all the screen points. Stored intensity values are then retrieved from the refresh buffer and “painted” on the screen one row (scan line) at a time as shown in the following illustration.



Raster Displays (Bitmap)

- Intensity for each pixel depends on the size of frame buffer
  - ex) Black & White system

Bitmap



Raster Displays (Pixmap)

– With multiple bits per pixel, we can display gray-scale or color pictures

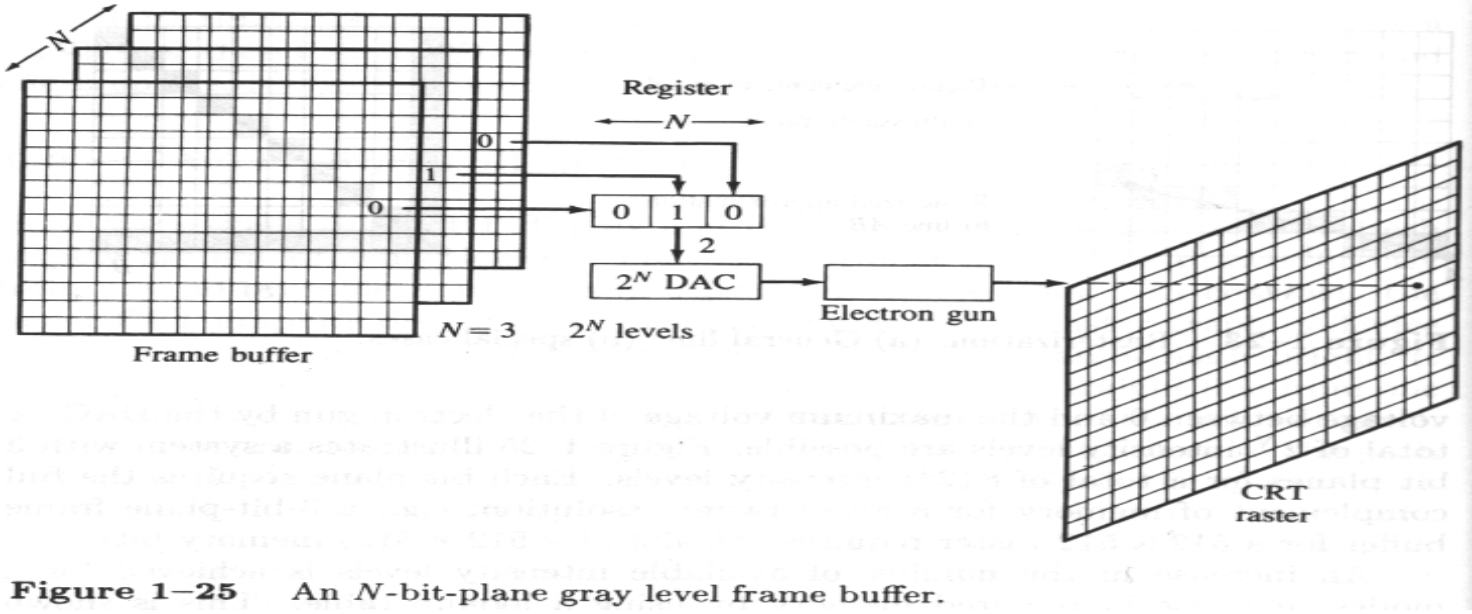


Figure 1–25 An N-bit-plane gray level frame buffer.

Ex) Size of Frame Buffer when N=3, with 512 X 512

Size of Frame buffer = 3 X 512 X 512 = 3 X 256k = 768k

	Raster Scan System	Random Scan System
Resolution	It has poor or **less Resolution** because picture definition is stored as a intensity value.	It has **High Resolution** because it stores picture definition as a set of line commands.
Electron-Beam	**Electron Beam** is directed from top to bottom and one row at a time on screen, but electron beam is directed to whole screen.	**Electron Beam** is directed to only that part of screen where picture is required to be drawn, one line at a time so also called **Vector Display**.
Cost	It is **less expensive** than Random Scan System.	It is **Costlier** than Raster Scan System.
Refresh Rate	Refresh rate is **60 to 80 frame per second**.	Refresh Rate depends on the number of lines to be displayed i.e **30 to 60 times per second**.
Picture Definition	It Stores **picture definition** in **Refresh Buffer** also called **Frame Buffer**.	It Stores picture definition as a set of **line commands** called **Refresh Display File**.
Line Drawing	**Zig – Zag line** is produced because plotted value are discrete.	**Smooth line** is produced because directly the line path is followed by electron beam .
Realism in display	It contains shadow, advance shading and hidden surface technique so gives the **realistic display** of scenes.	It does not contain shadow and hidden surface technique so it can not give realistic display of scenes.
Image Drawing	It uses **Pixels** along scan lines for drawing an image.	It is designed for line drawing applications and uses various mathematical function to draw.

Flat Panel Display

What does *Flat Panel Display* mean?

A flat panel display is a television, monitor or other display appliance that uses a thin panel design instead of a traditional cathode ray tube (CRT) design.

These screens are much lighter and thinner, and can be much more portable than traditional televisions and monitors. They also have higher resolution than older models.

LED display
Light-emitting diode (LED)

The 1,500-foot (460 m) long LED display on the Fremont Street Experience in Downtown Las Vegas, Nevada is currently the largest in the world.

- An **LED display** is a flat panel display, which uses an array of light-emitting diodes as pixels for a video display.

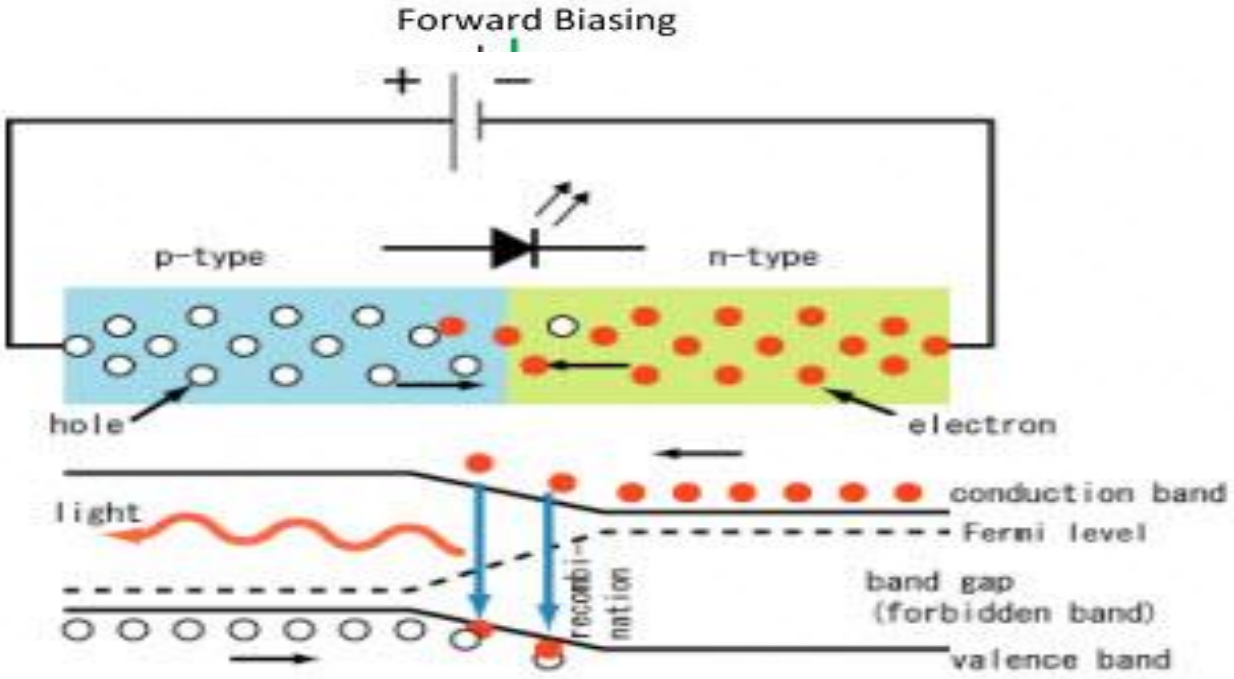
- In recent years they have also become commonly used in destination signs on public transport vehicles, as well as variable-message signs on highways.

- LED displays are capable of providing general illumination in addition to visual display.

- The first true all-LED flat panel television screen was possibly developed, demonstrated and documented by **James P. Mitchell in 1977**.
-

- The LED is a PN-junction diode which emits light when an electric current passes through it in the forward direction. In the LED, the recombination of charge carrier takes place.
- The electron from the N-side and the hole from the P-side are combined and gives the energy in the form of heat and light. The LED is made of semiconductor material which is colourless, and the light is radiated through the junction of the diode.
- The LEDs are extensively used in segmental and dot matrix displays of numeric and alphanumeric character.
- The several LEDs are used for making the single line segment while for making the decimal point single LED is used.

Working of LED



- The working of the LED depends on the quantum theory.
- The quantum theory states that when the energy of electrons decreases from the higher level to lower level, it emits energy in the form of photons.
- The energy of the photons is equal to the gap between the higher and lower level.

Working of LED

- The LED is connected in the forward biased, which allows the current to flows in the forward direction.
- The flow of current is because of the movement of electrons in the opposite direction.
- The recombination shows that the electrons move from the conduction band to valence band and they emits electromagnetic energy in the form of photons.
- The energy of photons is equal to the gap between the valence and the conduction band.

Applications of Light Emitting Diodes

- LED is used as a bulb in the homes and industries
- The light emitting diodes are used in the motorcycles and cars
- These are used in the mobile phones to display the message
- At the traffic light signals led's are used.

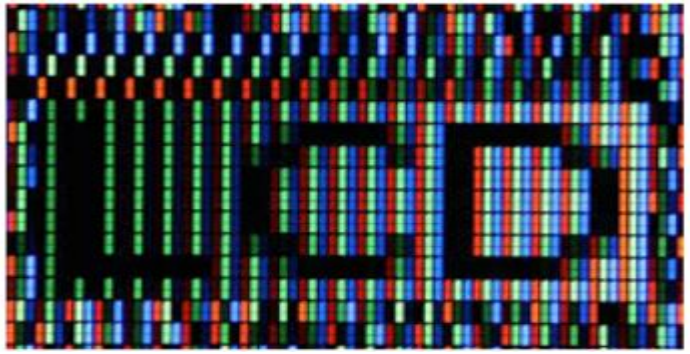
Advantages of LED's

- The cost of LED's is less and they are tiny.
- By using the LED's the electricity is controlled.
- The intensity of the LED differs with the help of the microcontroller.
- The LED are available which emits light in the different colors like red, yellow, green and amber.

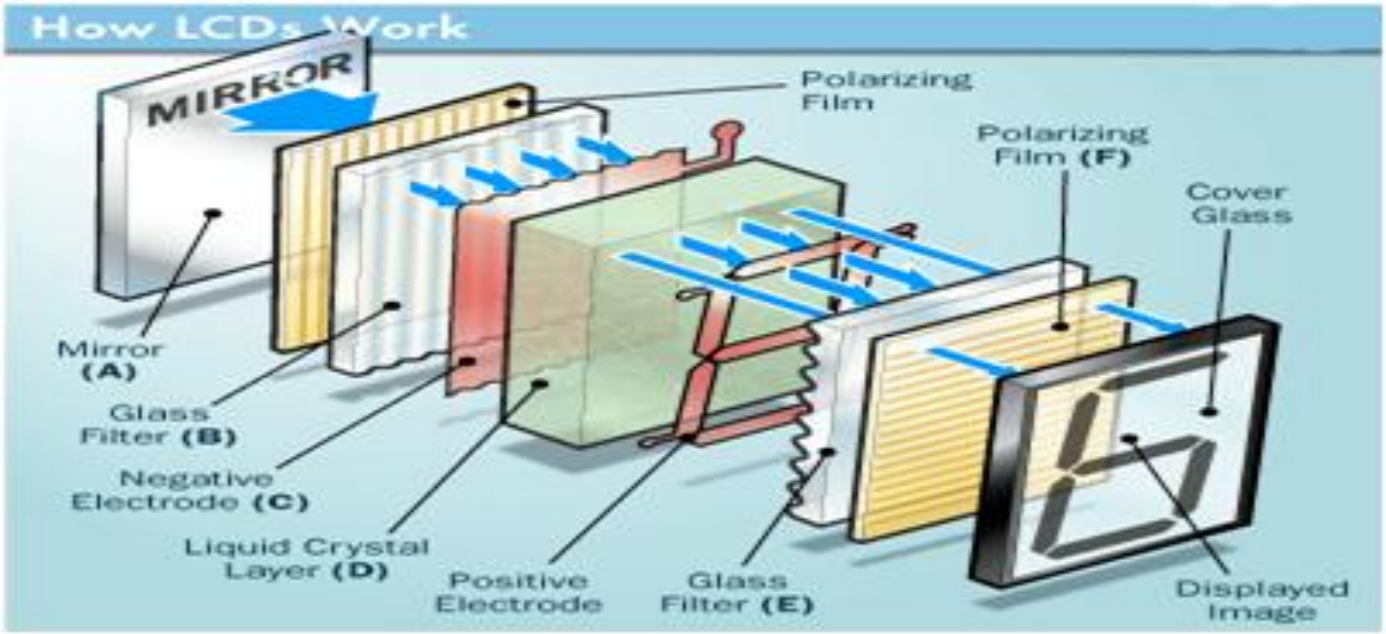
Disadvantages of LED

- The LED consume more power as compared to LCD, and their cost is high. Also, it is not used for making the large display.

Liquid-crystal display (LCD)



- It is combination of two states of matter, the solid and the liquid.
- LCD uses a liquid crystal to produce a visible image.
- Liquid crystal displays are super-thin technology display screen that are generally used in laptop computer screen, TVs, cell phones and portable video games.
- LCD's technologies allow displays to be much thinner when compared to cathode ray tube (CRT) technology.



Simple facts that should be considered while making an LCD:

- The basic structure of LCD should be controlled by changing the applied current.
- We must use a polarized light.
- Liquid crystal should able be to control both of the operation to transmit or can also able to change the polarized light.

Advantages of an LCD's:

- LCD's consumes less amount of power compared to CRT and LED
- LCDs are of low cost
- Provides excellent contrast
- LCD's are thinner and lighter when compared to cathode ray tube and LED

Disadvantages of an LCD's:

- Require additional light sources
- Range of temperature is limited for operation
- Low reliability
- Speed is very low

Applications of Liquid Crystal Display

- Liquid crystal thermometer ,Optical imaging, Used in the medical applications

Plasma Display Panel (PDP)

- A plasma display panel (PDP) is a type of flat panel display common to large TV displays 30 inches (76 cm) or larger.
- They are called "plasma" displays because they use small cells containing electrically charged ionized gases, which are plasmas.
- Plasma displays are thinner than cathode ray tube (CRT) displays and brighter than liquid crystal displays (LCD).

Touch Screen

- A touch screen is a computer display screen that is also an input device. The screens are sensitive to pressure; a user interacts with the computer by touching pictures or words on the screen.
- There are three types of touch screen technology:

- **Resistive**
- **Surface wave**
- **Capacitive**

Output primitives

- The Primitives are the simple geometric functions that are used to generate various Computer Graphics required by the User. Some most basic Output primitives are point-position(pixel), and a straight line.

- Line , polygon , marker , text

LINE ATTRIBUTES

- A straight-line segment can be displayed with three basic attributes: **color, width, and style.**
- Line color is typically set with the same function for all graphics primitives, while line width and line style are selected with separate line functions.
- Additionally, lines may be generated with other effects, such as pen and brush strokes.

To set line type attributes in a **PHICS** application program, a user invokes the function

setLinetype **(lt)**

where parameter l t is assigned a positive integer value of 1,2,3, or 4 to generate lines that are, respectively, solid, dashed, dotted, or dash-dotted.

Marker Attributes

A marker symbol is a single character that can he displayed in different colors and in different sizes. Marker attributes are implemented by procedures that load the chosen character into the raster at the defined positions with the specified color and size. We select a particular character to be the marker symbol with

setMarkerType (mt)

where marker type parameter mt is set to an integer code. Typical codes for marker type are the integers 1 through 5, specifying, respectively, a dot (.) a vertical cross (+), an asterisk (*), a circle (o), and a diagonal cross (X).

We set the marker size with

setMarkerSizeScaleFactor (ms)

with parameter marker size ms assigned a positive number. This scaling parameter is applied to the nominal size for the particular marker symbol chosen. Values greater than 1 produce character enlargement; values less than 1 reduce the marker size.

Functions Of graphics.h

- C graphics using graphics.h functions can be used to draw different shapes, display text in different fonts, change colors and many more.
- Using functions of graphics.h in Turbo C compiler you can make graphics programs, animations, projects, and games.
- You can draw circles, lines, rectangles, bars and many other geometrical figures. You can change their colors using the available functions and fill them.

void circle(int x, int y, int radius);

Circle function is used to draw a circle with center (x,y) and third parameter specifies the radius of the circle. The code given below draws a circle.

void closegraph();

closegraph function closes the graphics mode, deallocates all memory allocated by graphics system and restores the screen to the mode it was in before you called initgraph.

Virtual Reality

- Virtual reality (VR) means experiencing **things through our computers that don't really exist**.
- A believable, interactive 3D computer-created world that you can explore so you feel you really are there, both mentally and physically.

Putting it another way, virtual reality is essentially:

- **Believable**: You really need to feel like you're in your virtual world and to keep believing that, or the illusion of virtual reality will disappear.

- **Interactive**: As you move around, the VR world needs to move with you. You can watch a 3D movie and be transported up to the Moon or down to the seabed—but it's not interactive in any sense.

- **Computer-generated**: Only powerful machines, with realistic 3D computer graphics, are fast enough to make believable, interactive, alternative worlds that change in real-time as we move around them.

- **Explorable**: A VR world needs to be big and detailed enough for you to explore.

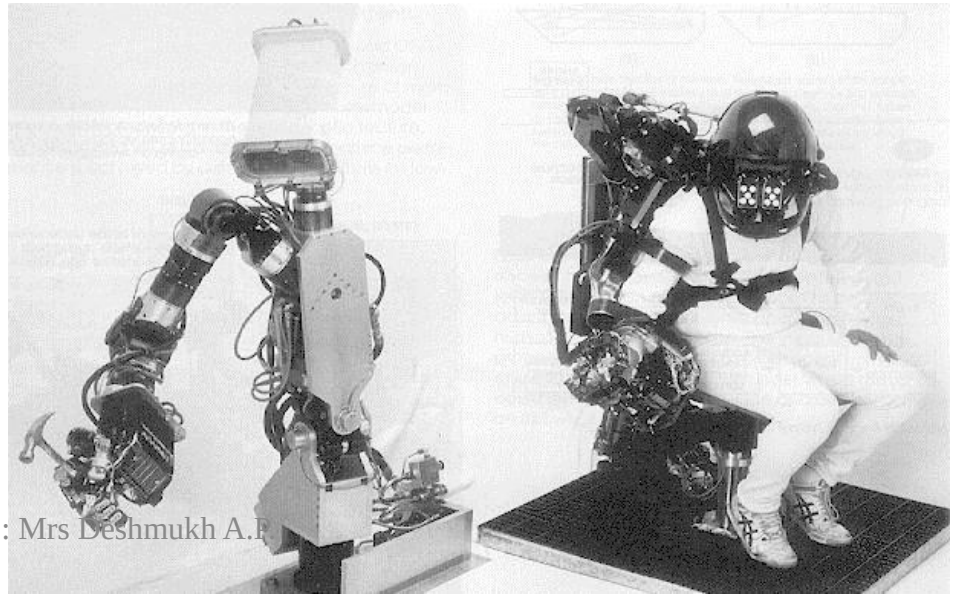
- **Immersive**: To be both believable and interactive, VR

Types of VR System

- Windows on World(WoW)
  - Also called Desktop VR.
  - Using a conventional computer monitor to display the 3D virtual world.
- Immersive VR
  - Completely immerse the user's personal viewpoint inside the virtual 3D world.
  - The user has no visual contact with the physical word.
  - Often equipped with a Head Mounted Display (HMD).

Types of VR System(Cont'd)

- Telepresence
  - A variation of visualizing complete computer generated worlds.
  - Links remote sensors in the real world with the senses of a human operator. The remote sensors might be located on a robot. Useful for performing operations in dangerous environments.



Types of VR System(Cont'd)

- Mixed Reality(Augmented Reality)
  - The seamless merging of real space and virtual space.
  - Integrate the computer-generated virtual objects into the physical world which become in a sense an equal part of our natural environment.

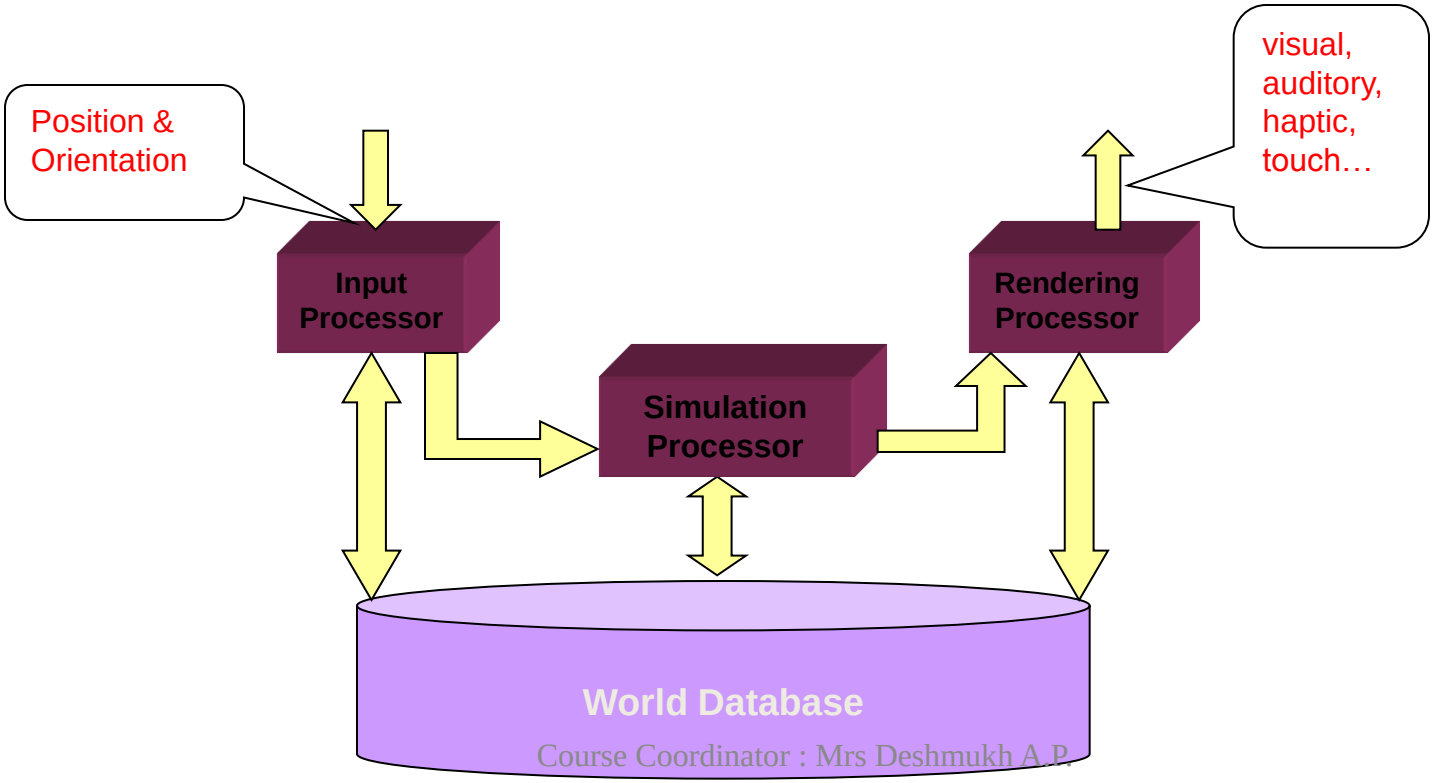
VR Examples (Cont'd)

Distributed VR

- A simulated world runs on several computers which are connected over network and the people are able to interact in real time, sharing the same virtual world.

Architecture of VR System

- Input Processor, Simulation Processor, Rendering Processor and World Database.



Components of VR System (Cont'd)

- Input Processor
  - Control the devices used to input information to the computer. The object is to get the coordinate data to the rest of the system with minimal lag time.
  - Keyboard, mouse, 3D position trackers, a voice recognition system, etc.

Components of VR System (Cont'd)

- Simulation Processor
  - Core of a VR system.
  - Takes the user inputs along with any tasks programmed into the world and determine the actions that will take place in the virtual world.

Components of VR System (Cont'd)

- Rendering Processor
  - Create the sensations that are output to the user.
  - Separate rendering processes are used for visual, auditory, haptic and other sensory systems. Each renderer take a description of the world stat from the simulation process or derive it directly from the World Database for each time step.

Components of VR System (Cont'd)

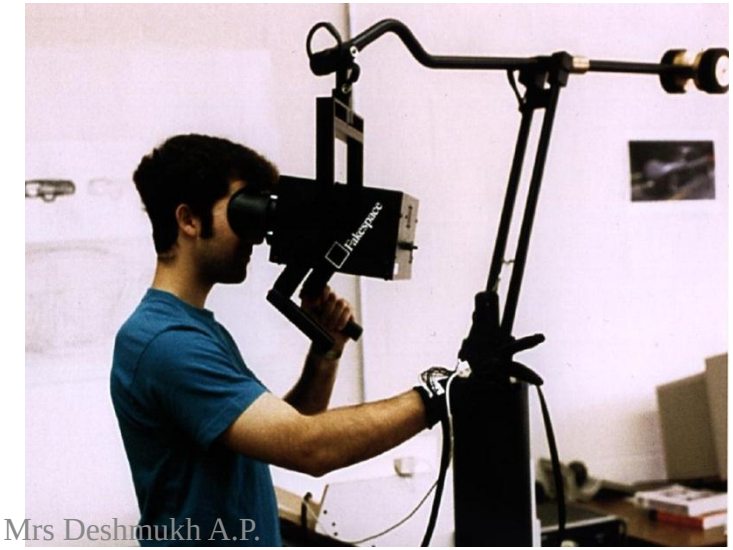
- World Database (World Description Files)
  - Store the objects that inhabit the world, scripts that describe actions of those objects.

Technologies of VR--Hardware

- Head-Mounted Display (HMD)
  - A Helmet or a face mask providing the visual and auditory displays.
  - Use LCD or CRT to display stereo images.
  - May include built-in head-tracker and stereo headphones

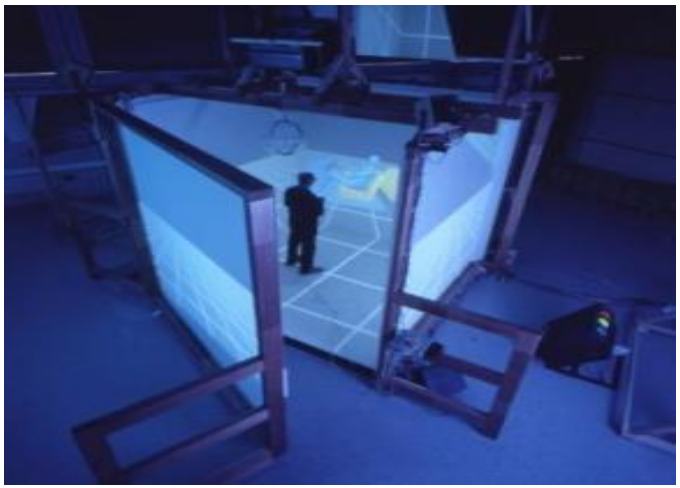
Technologies of VR--Hardware

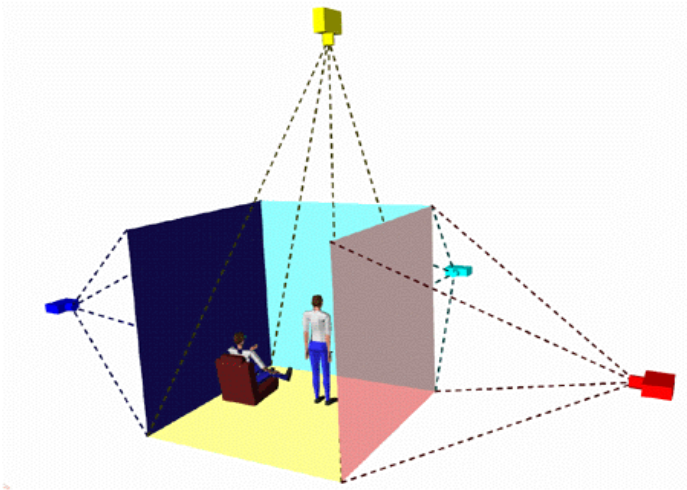
- Binocular Omni-Orientation Monitor (BOOM)
  - Head-coupled stereoscopic display device.
  - Uses CRT to provide high-resolution display.
  - Convenient to use.
  - Fast and accurate built-in tracking.



Technologies of VR--Hardware

- **Cave Automatic Virtual Environment (CAVE)**
  - Provides the illusion of immersion by projecting stereo images on the walls and floor of a room-sized cube.
  - A head tracking system continuously adjust the stereo projection to the current position of the leading viewer.





Technologies of VR--Hardware

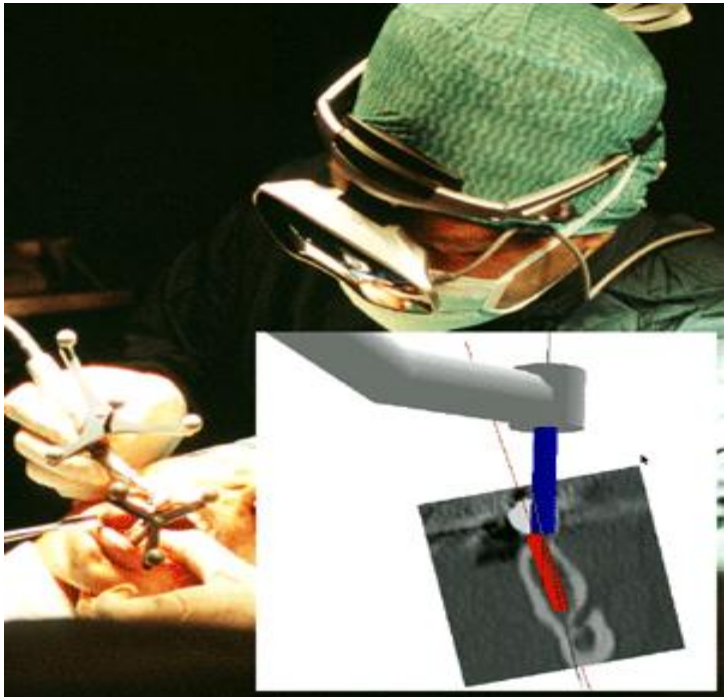
- Data Glove
  - Outfitted with sensors on the fingers as well as an overall position/orientation tracking equipment.
  - Enables natural interaction with virtual objects by hand gesture recognition.

Applications

- **Entertainment**
  - More vivid
  - Move exciting
  - More attractive

Applications (Cont'd)

- **Medicine**
  - Practice performing surgery.
  - Perform surgery on a remote patient.
  - Teach new skills in a safe, controlled environment.



Applications (Cont'd)

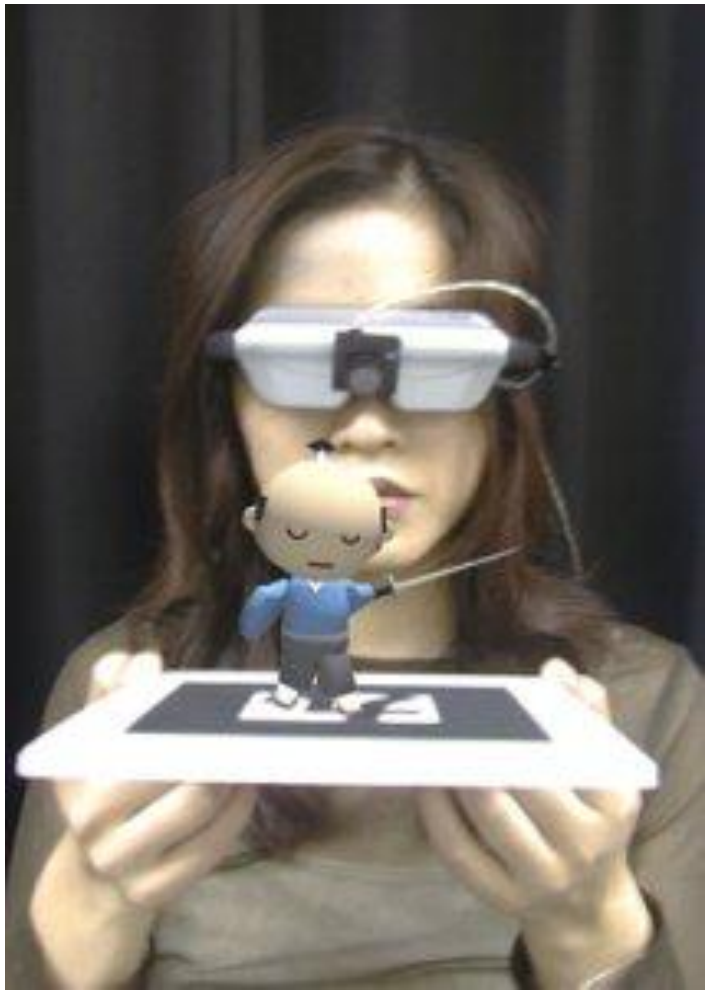
- Manufacturing
  - Easy to modify
  - Low cost
  - High efficient

Applications (Cont'd)

- Education & Training
  - Driving simulators.
  - Flight simulators.
  - Ship simulators.
  - Tank simulators.

What Is Augmented Reality (AR)?

- A combination of
  - a real scene viewed by a user and
  - a virtual scene generated by a computer that augments the scene with additional information.
  - ARToolkit demo movie
  - T-immersion 2004 video



What is AR? (cont.)

- Ronald Azuma defines an augmented reality system as one that:
  - Combines real and virtual world aspects
  - Is interactive in real-time
  - Is registered in three dimensions

Virtual Reality vs. Augmented Reality

- Virtual Reality (VR)

  a computer generated, interactive, 3D environment in which a person is immersed : virtual, interactive and immersive

- Augmented Reality (AR)

  Supplements the real world with the virtual(computer generated) objects that appear to coexist in the same space as the real world.

Augmented Reality vs. Virtual Reality

Augmented Reality

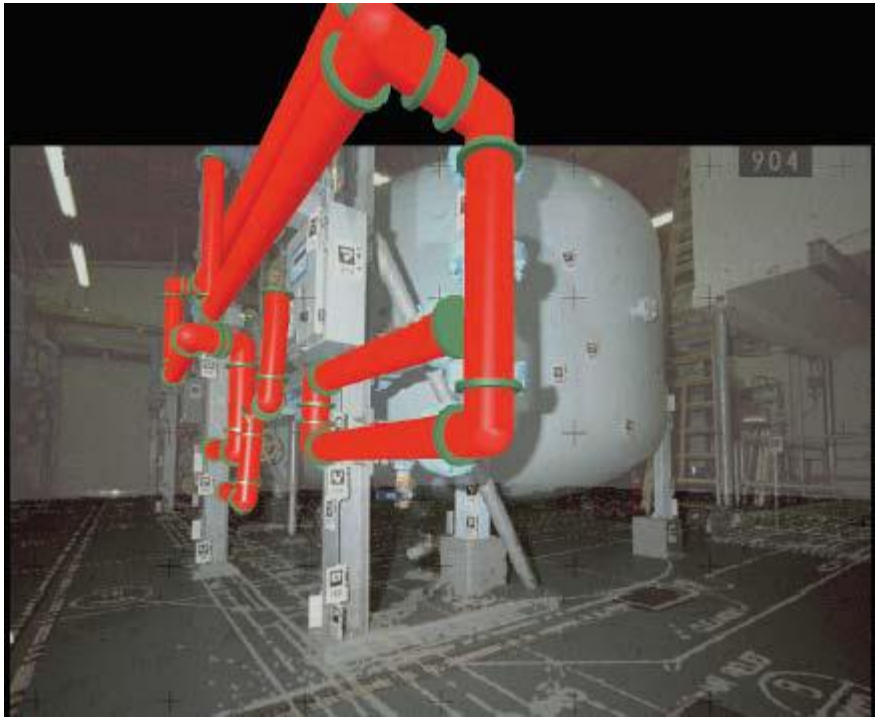
- System augments the real world scene
- User maintains a sense of presence in real world
- Needs a mechanism to combine virtual and real worlds
- Hard to register real and virtual

Virtual Reality

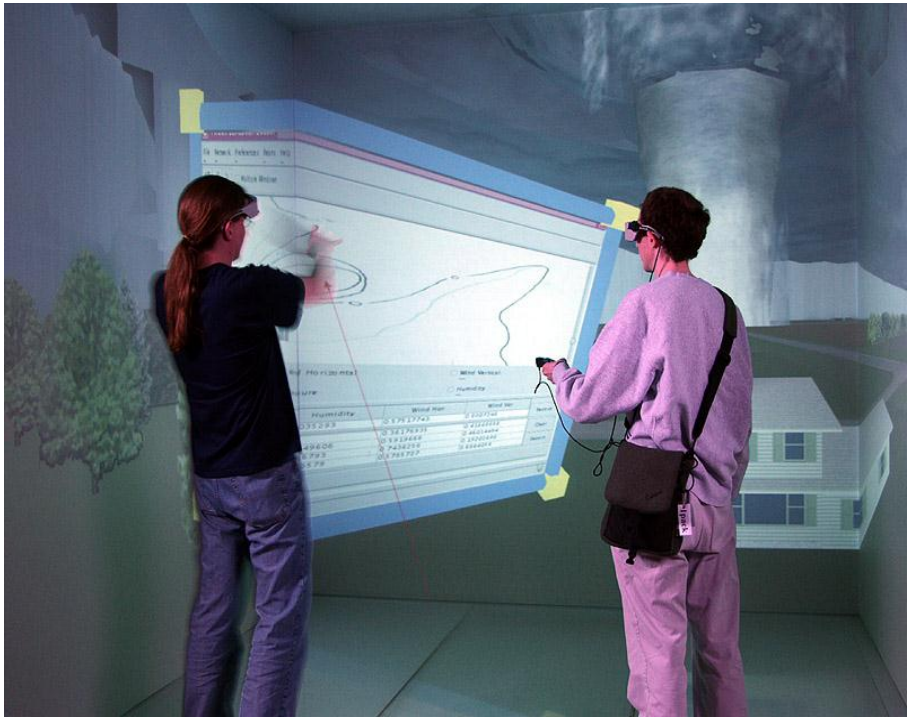
- Totally immersive environment
- Senses are under control of system
- Need a mechanism to feed virtual world to user
- Hard to make VR world interesting

Augmented Reality vs. Virtual Reality

Engineering



Education –Virtual Storm



What is needed?

- There are three components needed in order to make an augmented-reality system work:
  - Head-mounted display
  - Tracking system
  - Mobile computing power

Current Uses of AR

- Yellow first down line used on TV broadcasts of football games:
  - Real world elements: football field and players
  - Virtual element: the yellow line drawn over the image by computers in real-time

Current Uses of AR

- HUD (Head Up Display):
  - Used in commercial aircraft, automobiles, and other applications
  - Presents data without requiring the user to look away from his or her usual viewpoint

LifeClipper

- LifeClipper is a wearable AR system being used in Switzerland.

- When walking around a chosen culturally interesting area, the user will feel as though they are watching a film.

Wikitude – AR Travel Guide

- Mobile travel guide for the Android platform (open source OS for cell phones).
- Plan a trip or find about current surroundings in real-time.

Future of AR

- **Military**:
  - The Office of Naval Research has sponsored AR research
  - AR system could provide troops with vital information about their surroundings.
- **Medical**:
  - Superimpose an image from an MRI onto a patient's body.
  - This might allow surgeons to pinpoint a tumor to remove.
- **Education**:
  - Used in labs where students can learn more about the experiments they are participating in.

Future of AR

- **Gaming**:
  - ARQuake is an AR version of the popular game Quake.
    - 1st person shooter that allows the user to run around in the real world while playing a game in the computer generated world.
    - Uses GPS, a hybrid magnetic and interial orientation sensor, gun controller, and a standard laptop carried in a backpack.