UNIT - 2

Content

- Visual computation in virtual reality
- Fundamentals of computer graphics
- software and hardware technology on stereoscopic display

Visual computation in virtual reality

- **Visual computing** encompasses various computer science disciplines related to images and 3D models.
- **These fields collectively address tasks like computer graphics, image processing, visualization, computer vision, virtual and augmented reality, and video processing**
- **Computer Graphics**: This area focuses on creating and manipulating visual content. It involves rendering 2D and 3D scenes, modeling objects, simulating lighting, and generating realistic images. In **virtual reality (VR)**, computer graphics play a crucial role in rendering immersive environments that users can explore.
- **Image Processing**: Image processing deals with enhancing, analyzing, and manipulating digital images. Techniques include noise reduction, edge detection, and image restoration. In VR, image processing helps improve visual quality and reduce artifacts.

Visual computation in virtual reality

- **Visualization**: Visualization aims to represent complex data visually. In VR, this involves creating interactive 3D visualizations, such as architectural walkthroughs, medical scans, or scientific simulations.
- **Computer Vision**: Computer vision enables machines to interpret and understand visual information. In VR, it helps track user movements (e.g., head tracking) and recognize objects within the virtual environment.
- **Virtual Reality (VR)**: VR immerses users in simulated 3D environments. A VR system typically includes a **head-mounted display (HMD)** that tracks head movements and updates the displayed images accordingly. <u>Real-time rendering is crucial for maintaining a seamless experience</u>
- **Augmented Reality (AR)**: AR overlays virtual objects onto the real world. Users see both the physical environment and digital elements. AR systems require accurate real-time tracking and rendering to blend virtual and real content seamlessly.

Visual computation in virtual reality

- **Video Processing:** Video processing involves analyzing and manipulating video streams. In VR, this can include live video feeds (e.g., from cameras) integrated into the virtual environment.
- **Pattern Recognition:** Identifying patterns in visual data is essential for tasks like object recognition, gesture detection, and tracking.
- **Human-Computer Interaction (HCI):** HCI ensures intuitive interaction between users and VR systems. It includes designing user interfaces, gestures, and controllers.
- **Machine Learning:** ML techniques enhance visual computing by enabling systems to learn from data. For example, ML algorithms can improve image recognition or predict user preferences.

Fundamentals of computer graphics

- Graphics are defined as any sketch or a drawing or a special network that pictorially represents some meaningful information.
- Computer Graphics is used where a set of images needs to be manipulated or the creation of the image in the form of pixels and is drawn on the computer.
- Computer Graphics can be used in digital photography, film, entertainment, electronic gadgets, and all other core technologies which are required.
- It is a vast subject and area in the field of computer science.
- Computer Graphics can be used in UI design, rendering, geometric objects, animation, and many more. In most areas, computer graphics is an abbreviation of CG.
- There are several tools used for the implementation of Computer Graphics.
- The basic is the <graphics.h> header file in Turbo-C, Unity for advanced and even OpenGL can be used for its Implementation.

Types of Computer Graphics

Two types of computer graphics

1. Interactive
2. Passive Graphics

- Non-Interactive or Passive Computer Graphics:

➢ In non-interactive computer graphics, the picture is produced on the monitor, and the user does not have any controlled over the image, i.e., the user cannot make any change in the rendered image. One example of its Titles shown on T.V.

➢ Non-interactive Graphics involves only one-way communication between the computer and the user, User can see the produced image, and he cannot make any change in the image.

- <u>Interactive Computer Graphics:</u>

➢In interactive Computer Graphics user have some controls over the picture, i.e., the user can make any change in the produced image. One example of it is the ping-pong game.

➢Interactive Computer Graphics require two-way communication between the computer and the user. A User can see the image and make any change by sending his command with an input device.

- Advantages:

➢Higher Quality

➢More precise results or products

➢Greater Productivity

➢Lower analysis and design cost

➢Significantly enhances our ability to understand data and to perceive trends.

Applications

Computer Graphics are used for an **aided design for engineering and architectural system-** These are used in electrical automobiles, electro-mechanical, mechanical, electronic devices. For example gears and bolts.

Computer Art – MS Paint.

Presentation Graphics – It is used to summarize financial statistical scientific or economic data. For example- Bar chart, Line chart.

Entertainment- It is used in motion pictures, music videos, television gaming.

Education and training- It is used to understand the operations of complex systems. It is also used for specialized system such for framing for captains, pilots and so on.

Visualization- To study trends and patterns. For example- Analyzing satellite photo of earth.

Display Devices

- Display devices are also known as output devices.
- Most commonly used output device in graphics system is a video monitor.
- Display devices are designed to model, display, view, or display information.

The purpose of display technology is to simplify information sharing.

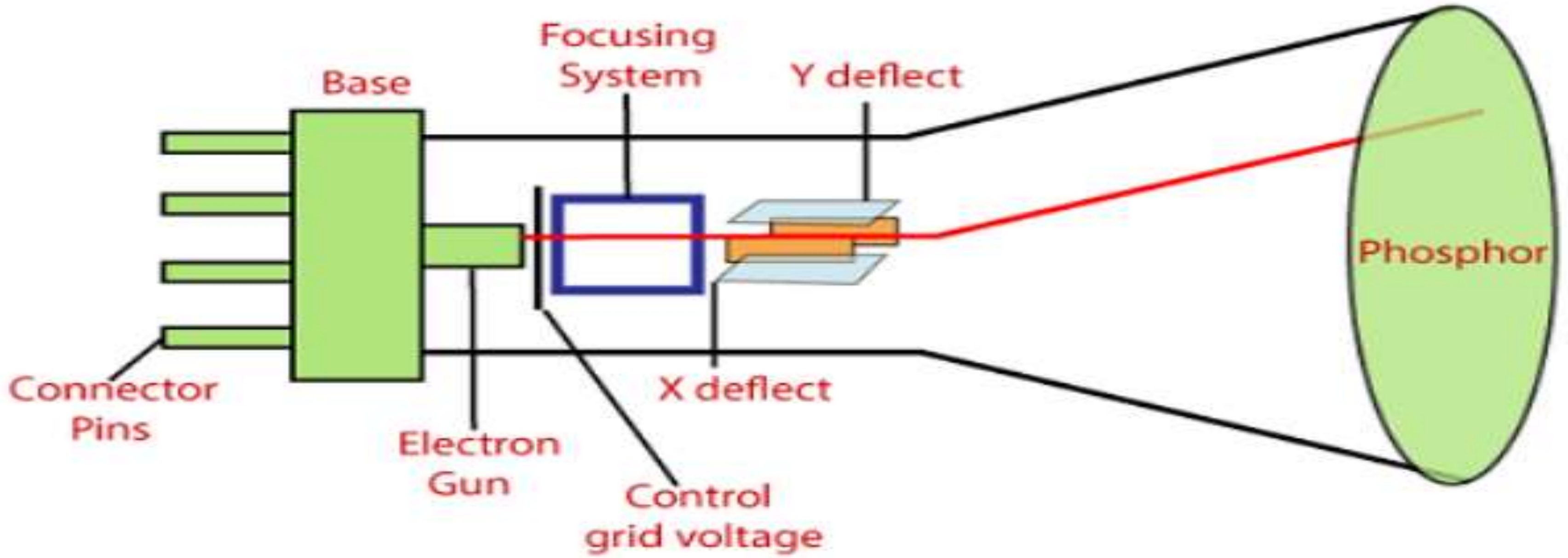
- There are some display devices given below:

1. Cathode-Ray Tube(CRT)
2. Color CRT Monitor
3. Liquid crystal display(LCD)
4. Light Emitting Diode(LED)
5. Direct View Storage Tubes(DVST)
6. Plasma Display
7. 3D Display

Cathode-ray Tube (CRT):

• CRT stands for Cathode ray tube. It is a technology which is used in traditional computer monitor and television.

• Cathode ray tube is a particular type of vacuum tube that displays images when an electron beam collides on the radiant surface.



Component of CRT

- **Electron Gun:** The electron gun is made up of several elements, mainly a heating filament (heater) and a cathode. The electron gun is a source of electrons focused on a narrow beam facing the CRT.
- **Focusing & Accelerating Anodes:** These anodes are used to produce a narrow and sharply focused beam of electrons.
- **Horizontal & Vertical Deflection Plates:** These plates are used to guide the path of the electron the beam. The plates produce an electromagnetic field that bends the electron beam through the area as it travels.
- **Phosphorus-coated Screen:** The phosphorus coated screen is used to produce bright spots when the high-velocity electron beam hits it.

- There are two ways to represent an object on the screen:
  - Raster Scan
  - Random Scan (Vector scan)
- Raster Scan: It is a scanning technique in which the electron beam moves along the screen. It moves from top to bottom, covering one line at a time.
- A raster scan is based on pixel intensity control display as a rectangular box on the screen called a raster.
- Picture description is stored in the memory area called as Refresh buffer, or Frame Buffer.
- Frame buffer is also known as Raster or Bitmap. Raster scan provides the refresh rate of 60 to 80 frames per second.
- For Example: Television

- **Advantages:**
    - Real image
    - Many colors to be produced
    - Dark scenes can be pictured
- **Disadvantages:**
    - Less resolution
    - Display picture line by line
    - More costly

• Random Scan (Vector scan): It is also known as stroke-writing display or calligraphic display. In this, the electron beam points only to the area in which the picture is to be drawn.

• It uses an electron beam like a pencil to make a line image on the screen. The image is constructed from a sequence of straight-line segments. On the screen, each line segment is drawn by the beam to pass from one point on the screen to the other, where its x & y coordinates define each point.

• After compilation of picture drawing, the system cycle back to the first line and create all the lines of picture 30 to 60 times per second.

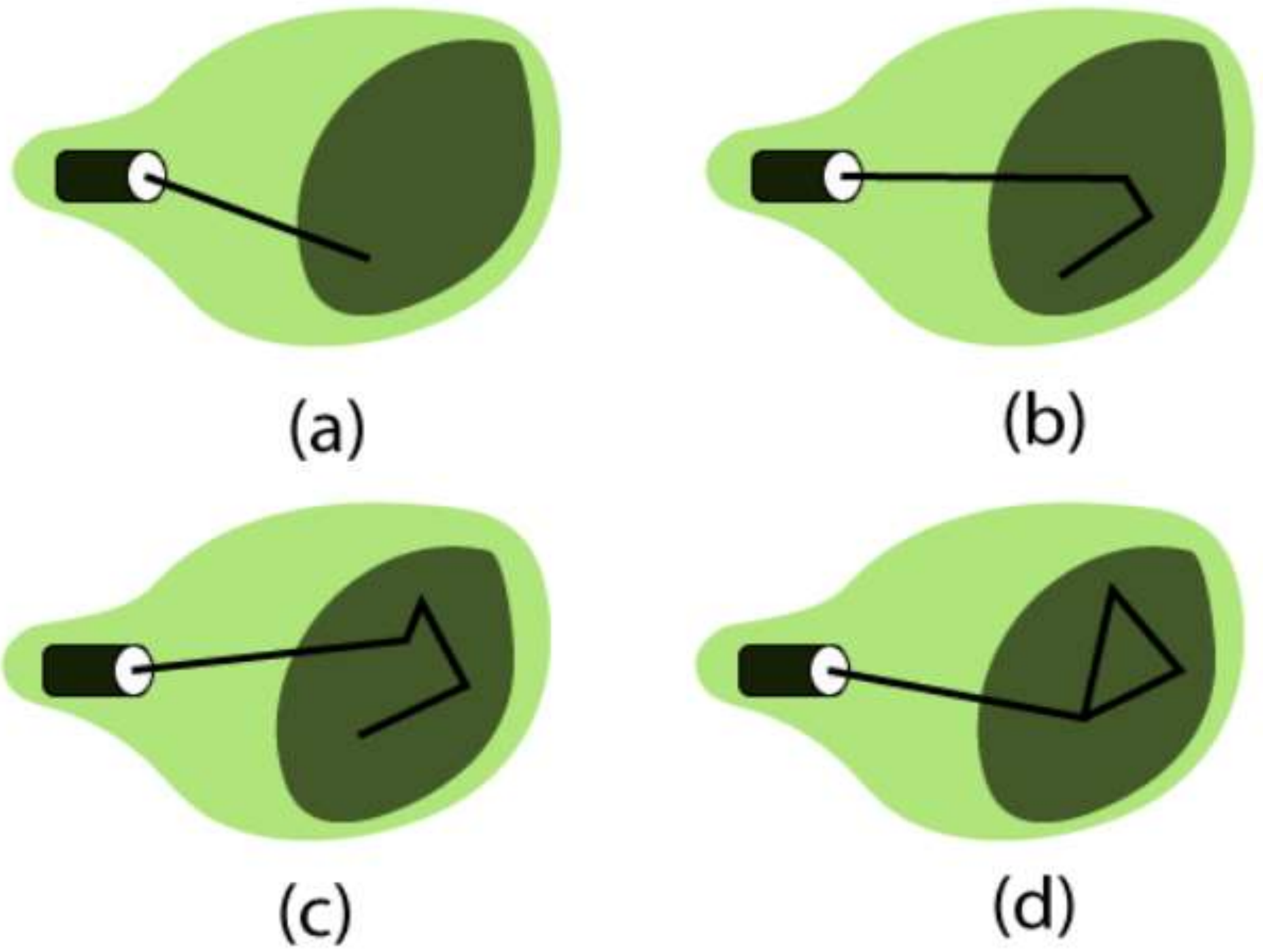


Fig: A Random Scan display draws the lines of an object in a specific order

- Advantages:
    - High Resolution
    - Draw smooth line Drawing
- Disadvantages:
    - It does only the wireframe.
    - It creates complex scenes due to flicker.

Color CRT Monitor:

•The basic idea behind the color CRT monitor is to combine three basic colors- Red, Green, and Blue. By using these three colors, we can produce millions of different colors.

• The two basic color display producing techniques are:

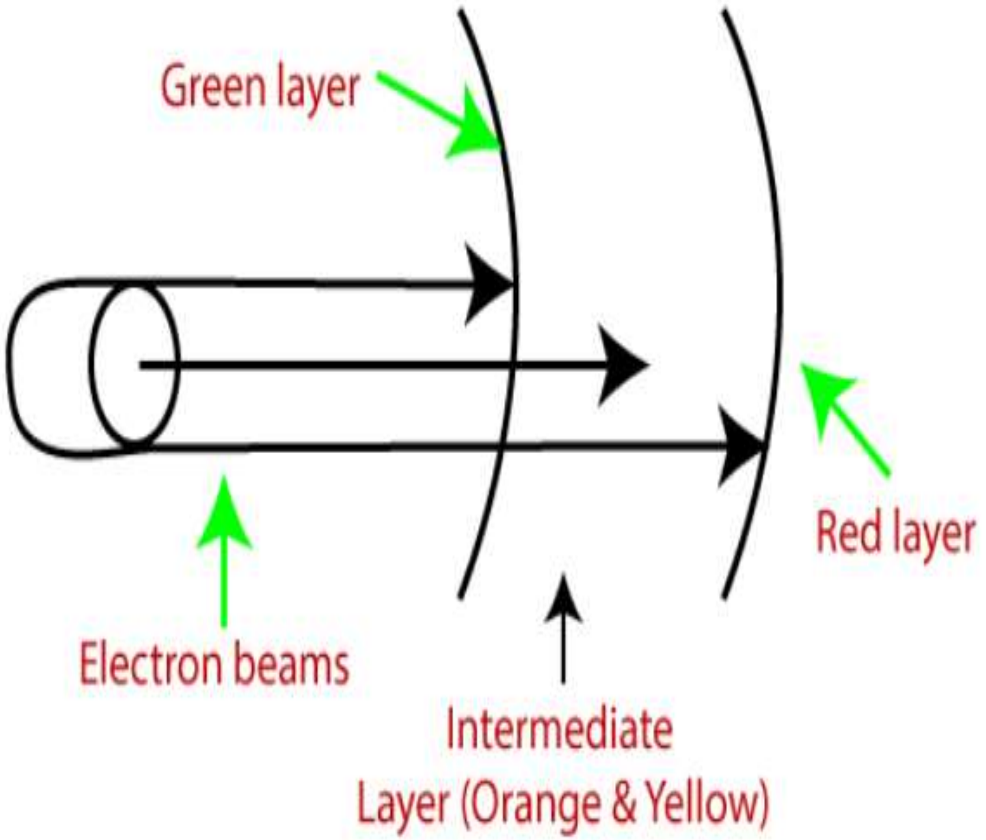
•**Beam-Penetration Method:** It is used with a random scan monitor for displaying pictures. There are two phosphorus layers- Red and Green are coated inside the screen. The color shown depends on how far the electron beam penetrates the phosphorus surface.

•A powerful electron beam penetrates the CRT, it passes through the red layer and excites the green layer within.

•A beam with slow electrons excites only the red layer.

•A beam with the medium speed of electrons, a mixture of red and green light is emitted to display two more colors- orange and yellow.

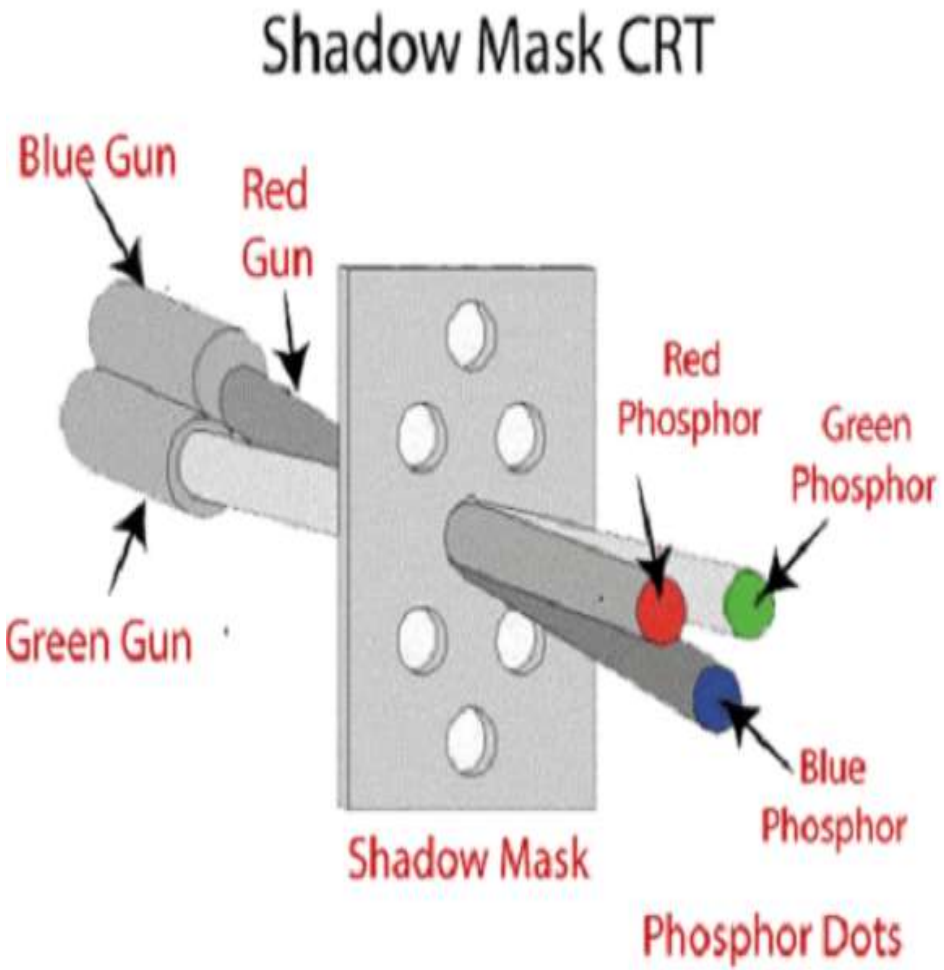
- **Advantages:**
    - Better Resolution
    - Half cost
    - Inexpensive
- **Disadvantages:**
    - Only four possible colors
    - Time Consuming



- **Shadow-Mask Method:** It is used with a raster scan monitor for displaying pictures. It has more range of color than the beam penetration method. It is used in television sets and monitors.
- **Structure:**
- It has three phosphorus color dots at each position of the pixel.
- First Dot: Red color
- Second Dot: Green color
- Third Dot: Blue color
- It has three different guns. Each for one color.
- It has a metal screen or plate just before the phosphorus screen, named “Shadow-Mask.”
- It also has a shadow grid just behind the phosphorus coated screen with tiny holes in a triangular shape.

- **Working:** A Shadow Mask is a metal plate with tiny holes present inside a color monitor.
- A Shadow Mask directs the beam by consuming the electrons so that the beam hits only the desired point and displays a resulting picture.
- It has three different guns. These guns direct their beams to shadow mask, which allows them to pass. It is a task of a shadow mask to direct the beam on its particular dot on the screen and produce a picture on the screen.
- A Shadow Mask can display a wider range of pictures than beam penetration.

Advantages:
•Display a wider range picture.
•Display realistic images.
•In-line arrangement of RGB color.
Disadvantages:
•Difficult to cover all three beams on the same hole.
•Poor Resolution.



Liquid crystal display (LCD):

- The LCD depends upon the light modulating properties of liquid crystals.
- LCD is used in watches and portable computers. LCD requires an AC power supply instead of DC, so it is difficult to use it in circuits.
- It generally works on flat panel display technology. LCD consumes less power than LED. The LCD screen uses the liquid crystal to turn pixels on or off.
- Liquid Crystals are a mixture of solid and liquid. When the current flows inside it, its position changes into the desired color.
- For Example: TFT (Thin Film Transistor)

Advantages:
- Produce a bright image
- Energy efficient
- Completely flat screen

Disadvantages:
- Fixed aspect ratio & Resolution
- Lower Contrast
- More Expensive

Light Emitting Diode (LED):

- LED is a device which emits when current passes through it. It is a semiconductor device.
- The size of the LED is small, so we can easily make any display unit by arranging a large number of LEDs.
- LED consumes more power compared to LCD. LED is used on TV, smartphones, motor vehicles, traffic light, etc.
- LEDs are powerful in structure, so they are capable of withstanding mechanical pressure. LED also works at high temperatures.

Advantages:

- The Intensity of light can be controlled.
- Low operational Voltage.
- Capable of handling the high temperature.

Disadvantages:

- More Power Consuming than LCD.

Direct View Storage Tube (DVST):

- It is used to store the picture information as a charge distribution behind the phosphor-coated screen.
- There are two guns used in DVST:

- **Primary Gun:** It is used to store the picture information.
- **Flood / Secondary Gun:** It is used to display a picture on the screen.

Advantages:

•Less Time Consuming

•No Refreshing Required

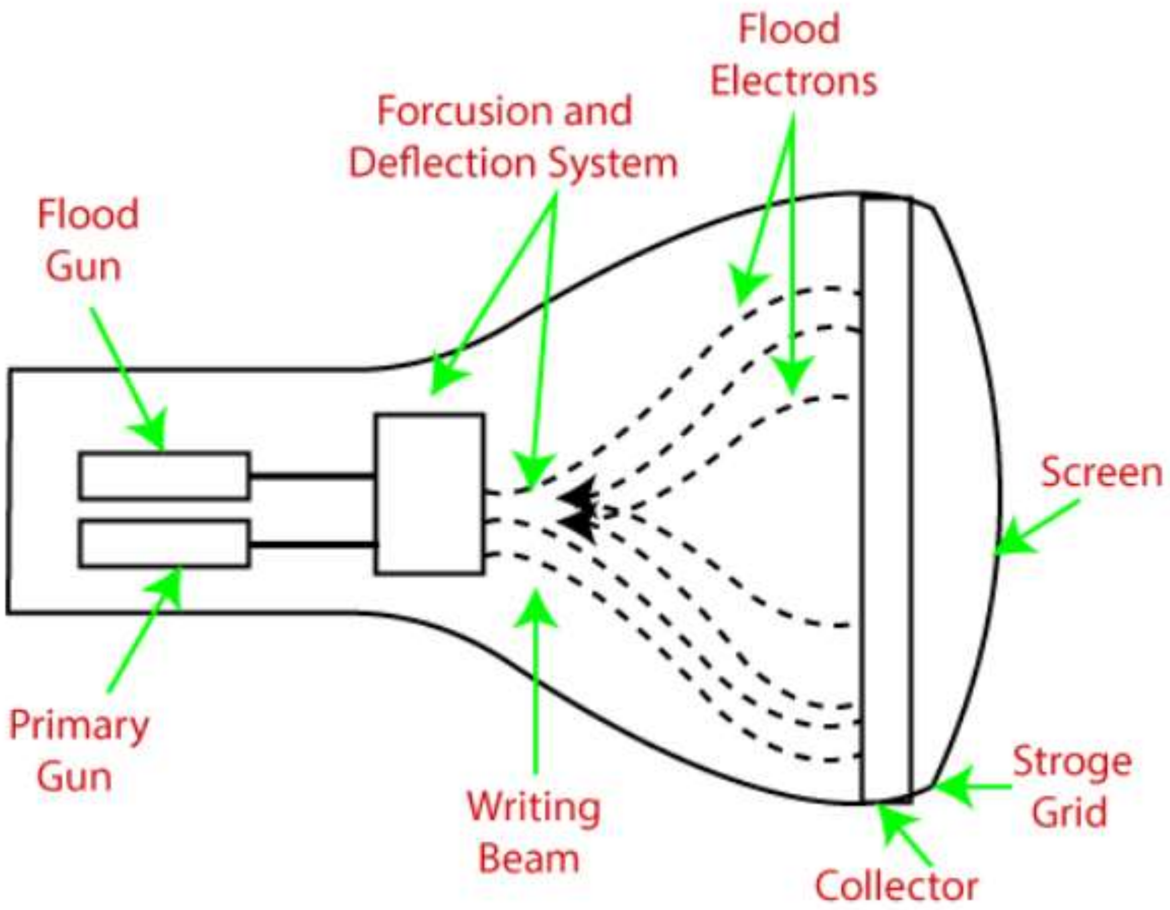
•High-Resolution

•Less Cost

Disadvantages:

• The specific part of the image cannot be erased.

• They do not display color.



Plasma Display:

It is a type of flat panel display which uses tiny plasma cells. It is also known as **the Gas-Discharge display**.

Components of Plasma display

- **Anode:** It is used to deliver a positive voltage. It also has the line wires.
- **Cathode:** It is used to provide negative voltage to gas cells. It also has fine wires.
- **Gas Plates:** These plates work as capacitors. When we pass the voltage, the cell lights regularly.
- **Fluorescent cells:** It contains small pockets of gas liquids when the voltage is passed to this neon gas. It emits light.

Advantages:

•Wall Mounted

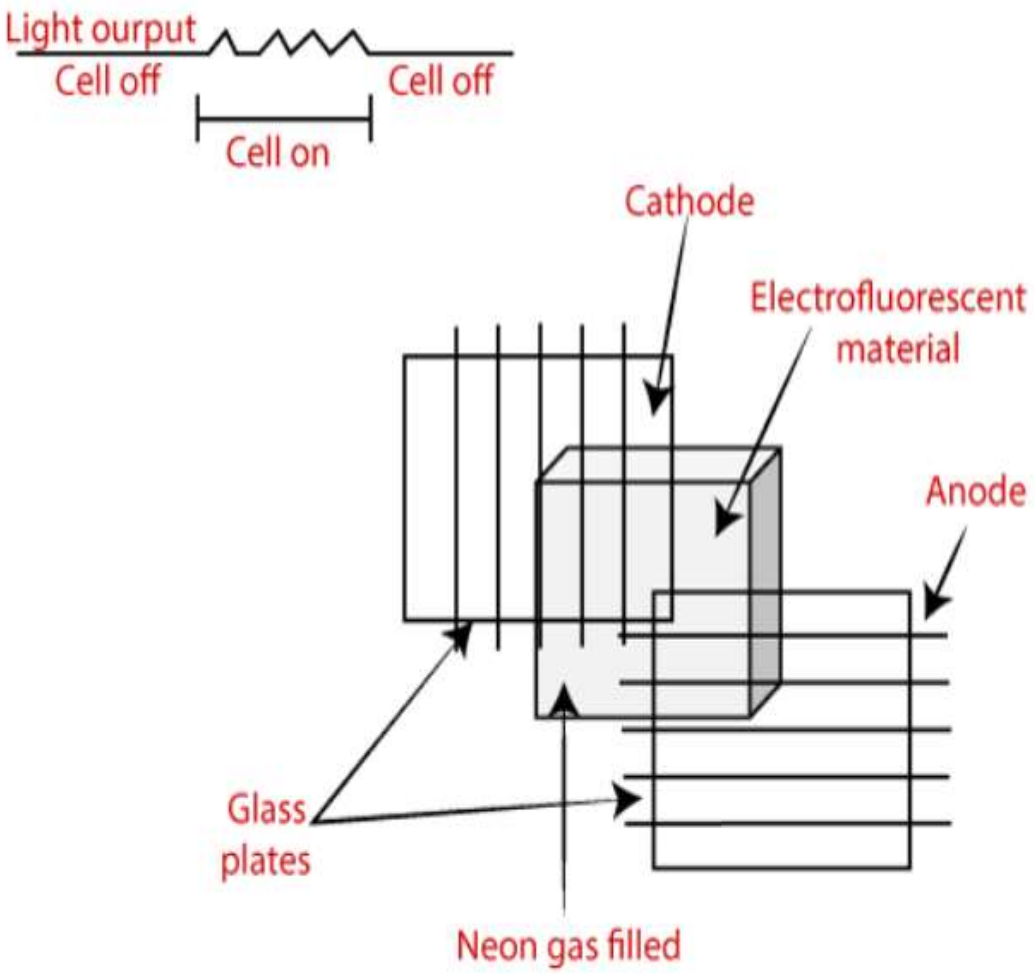
•Slim

•Wider angle

Disadvantages:

•It consumes more electricity than LCD.

•Large Size



3D Display:

•It is also called stereoscope display technology. This technology is capable of bringing depth perception to the viewer.
•It is used for 3D gaming and 3D TVs.
•**For Example:** Fog Display, Holographic Display, Retina Display Etc.

Advantages:
•Impressive Picture Quality
Disadvantage:
•Expensive
•Binocular Fusion

Input-Output Devices

- These Devices include:
  - Keyboard
  - Mouse
  - Trackball
  - Spaceball
  - Joystick
  - Light Pen
  - Touch Panels
  - Voice Recognition
  - Image Scanner
  - Printers
  - Plotters

Display Processor

- It is a part of hardware or interpreter which is used to transform display processor code into pictures. It is used to convert digital information from CPU to analog data.

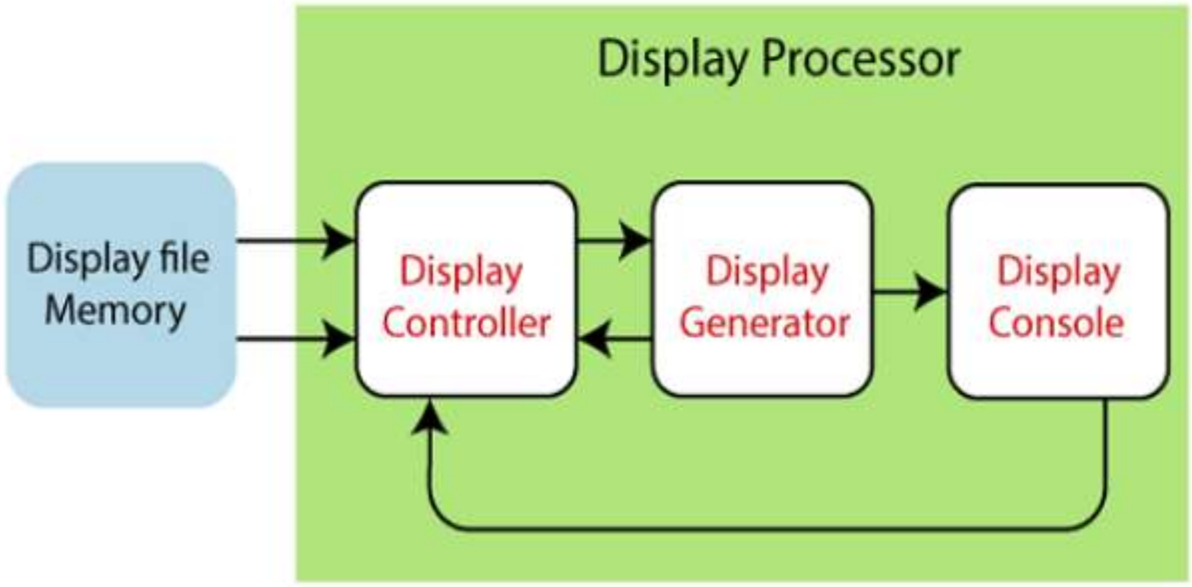
- It is a digital-analog conversion which depends on the types of devices and graphics functions. The main function of display processors is called scan conversion.

- In this process, contiguous graphics objects have to be separated as collections of ellipse, rectangles, and polygons.

- The display processor is also sometimes called a display processing unit (DPU).

• **Parts of Display Processor:** It has the following four parts:

- ❑ Display Controller
- ❑ Display File Memory
- ❑ Display Generator
- ❑ Display Console



Block diagram of Display System

- **Display Controller:** It is also called the Video controller. It is used to control the operations of the display device. Its functions are as follows:
    - It is used to handle the interrupt.
    - It is used to interpret the instructions.
    - It is also used to manage time.

- **Display File Memory:** It is used to create an image. It is also used for visual object recognition and identification of graphics entities.

- **Display Generator:** It is used to produce the character. It is also used to create curves.

- **Display Console:** It consists of a CRT, Light pen, keyboard, and Deflection system.

Working of Display Processor

The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep. Its beam across the screen during raster scans.

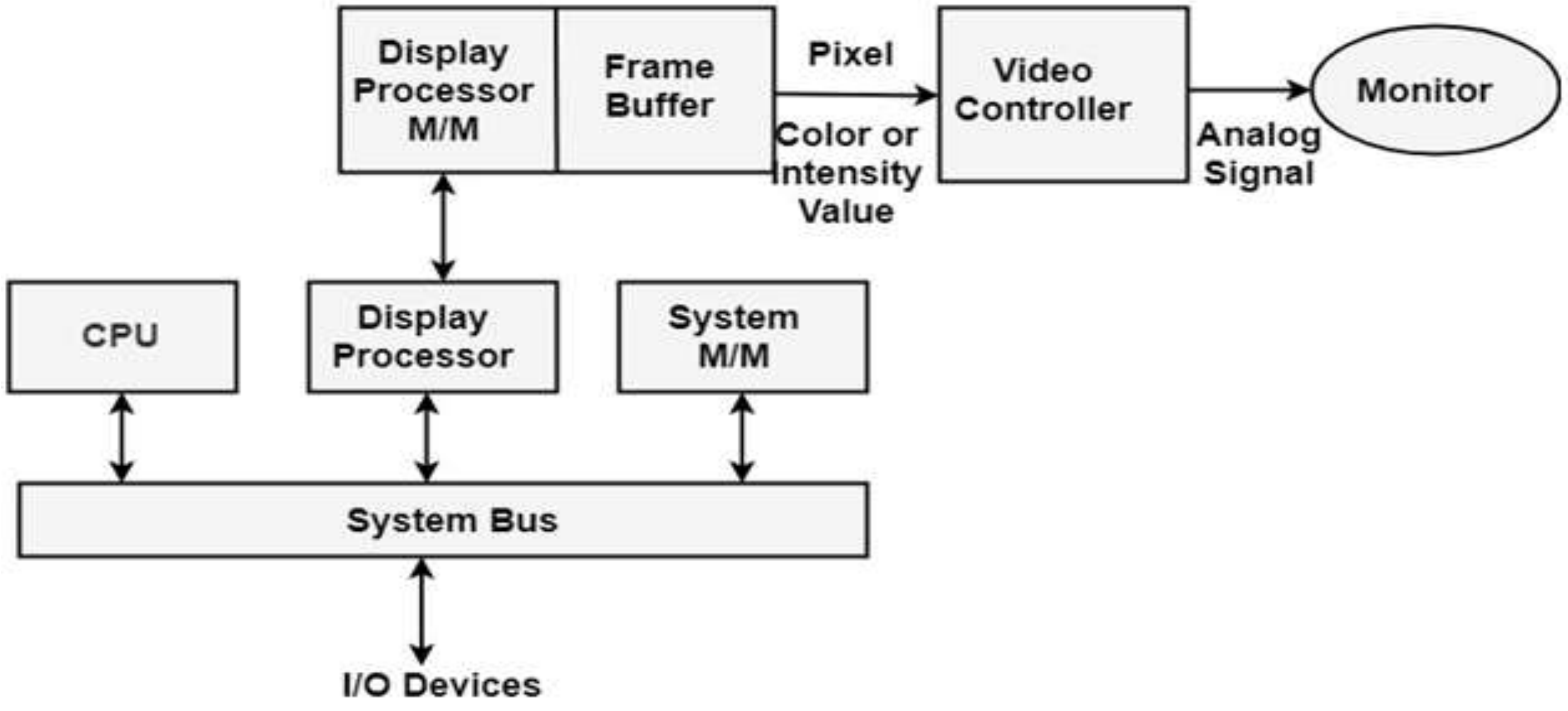


Fig: Architecture of a Raster Display System with a Display Processor

Features of Display Processor:

- It is used to perform operations such as different line styles, displaying color area, and manipulating and transforming objects on display.

- Display Processors were used before the GPU (Graphics Display Processor).

- Video Controller is the widely used Display device that is base on CRT (Cathode Ray Tube).

- The Display Processor has a separate memory area in addition to the system memory.

Animation in Computer Graphics

- The Animation is a technology that allows any image object, an entity to walk, talk, or do some movement that cannot be physically moved.
- We use many images to create an animation. The images which have a different reaction, run it together one after another at high speed than the images look- real.
- Computer Animation is an art to produce moving images. We can define it as a subfield of computer graphics and animation. When we use animation in a movie or film, it is called CGI (Computer Generated Imaging).

- Application Areas of Animation

Animation is used in various fields. They are:

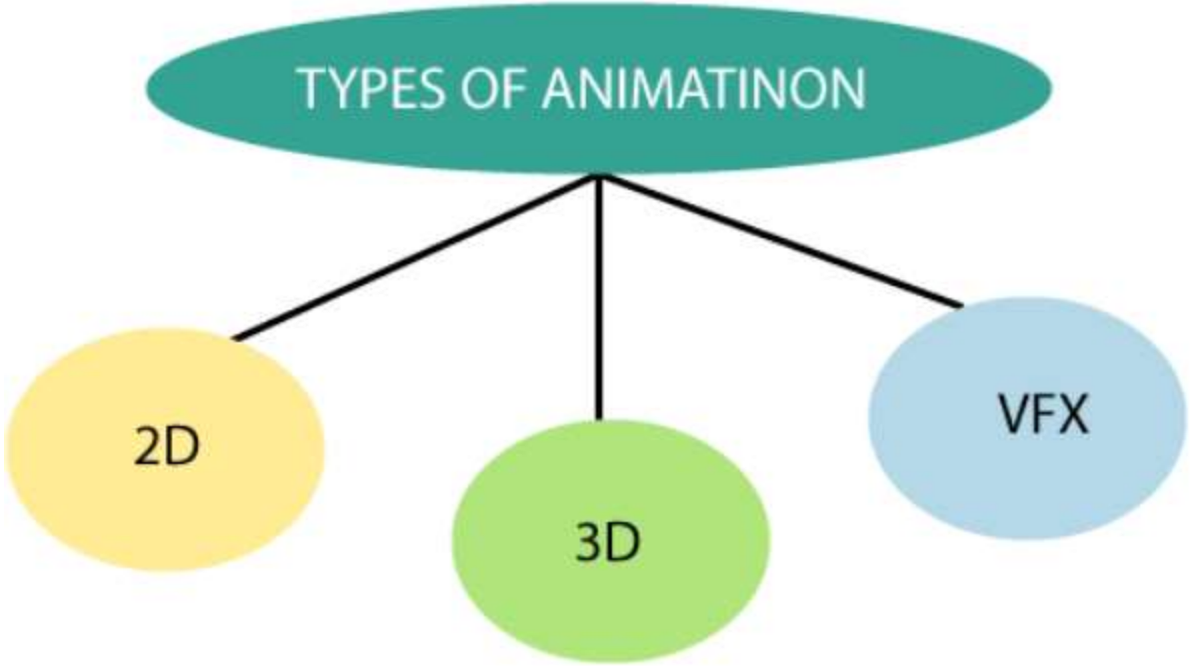
Education: An animated video or animated tutorial is used to increase the learning of the students. The animation is mostly used in schools, colleges, and training centers.

Entertainment: It is a vast area where we can use animations. Various animation methods are used in cartoons, movies, motion pictures, and TV shows.

Advertisement: Animation is also used to make ad films that take less space and captures the vast attention of the people. It is a better way to provide more information about products.
Medical: Animation is used in medical science. The professionals and the students can easily visualize the details of human anatomy through medical animation.
Retail: The marketers use animation to present the attributes of products to the customers.
Computer-Aided Design: Animation plays an important role in CAD. We can use CAD in automobile designing and many other designing.
Gaming: Animation is widely used in gaming. We can develop 3D games by using animation.
Presentation: We can present anything through an animated presentation. Animated presentation is a better way to represent an idea.

Types of Animation

The Animation is divided into three parts.



2D

- **2D:** It is also called **“2 Dimensional.”**2D animation is defined as a process of producing characters, storyboards, and backgrounds in a two-dimensional environment.
- 2D animation is a flat animation that only works on two coordinates x-axis(horizontal) and y-axis(vertical).
- The 2D animation uses raster and vector graphics to produce and edit animated images.
- **For Example**- Cartoons
- **The software used in 2D animation is:**
    - Adobe Photoshop
    - Adobe Flash
    - After Effects
    - Encore

- **Advantages:**
- Easy to Control.
- Less Time-Consuming.
- Less Production Cost.
- Easy to change.
- **Disadvantages:**
- Need proper skills to use animation software.

3D

- It is also called **"3 Dimensional."** 3D animation is defined as the process of producing three-dimensional motion images in the digital environment. 3D Animation is used to create animated scenes through the computer.
- We can manipulate 3D objects or models through the 3D animation software.
- 3D animation works on all three coordinates x-axis(height), y-axis(width) and z-axis(depth).
- **For Example-**
- Toy Story
- Jurassic Park
- The Transformers

•**The software used in 3D animation is:**
•ZBrush
•Houdini
•Blender
•Autodesk Maya
•**The process of producing 3D animations is divided into three parts:**
•**Modeling:** It is a phase in which we can describe the creation of 3D objects within a specific scene.
•**Layout and Animation:** It is a phase in which we can describe how objects are positioned and animated within a scene.
•**Rendering:** It is a final process. It is a phase in which we can convert 3D objects or images into 2D objects or images.

- **Advantages:**
- Motion Communication
- More Realistic
- Reusable
- **Disadvantages:**
- Lack of purity
- Limited Thought and Ideas

VFX

VFX: It is also called **“Visual Effects.”** It is a process in which we can make a mixture of real shooting (special effects) with animated images (digital effects). It is mostly and widely used in movie making.

For Example-

In a movie, we will see the hero flying into the air by using VFX effects.

In the Jurassic Park movie, the dinosaurs are also created by using VFX effects.

The Software used in VFX animation:

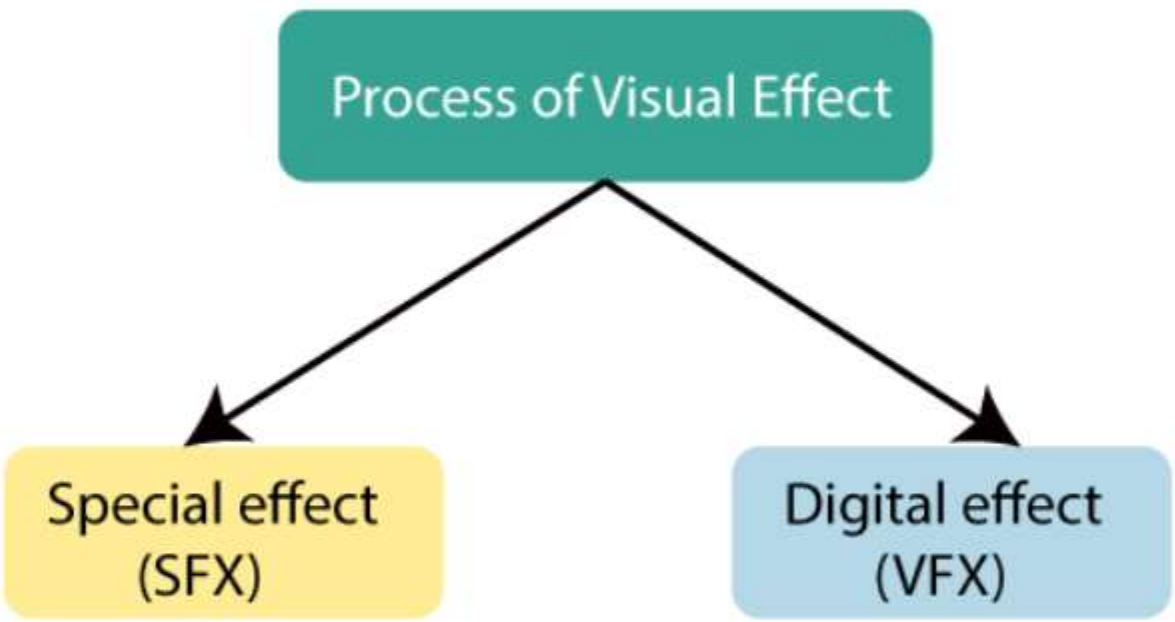
Nuke

After effects

3D Studio Max

Adobe Creative Suite 4

This process has been done in two parts-



- **Special effects (SFX):** The special effects cover all visual effects that occur in live-action.
- **For Example-** Stunt, Any Explosion on set.
- **Digital Effects (VFX):** It is also called **"Visual effects."** It includes different steps by which photographic assets can create, and imagery can manipulate.
- Digital effects mostly include a combination of real photography and computer-aided imagery to create a realistic environment. The environment would be impossible, costly, and sometimes very dangerous to shoot in-camera.
- **Advantages:**
- It helps to show unreal objects.
- It saves a lot of time.
- **Disadvantages:**
- Need a Lot of Planning.
- Overuse of Visual Effects

Animation Function

There are different functions to create animation

1. Morphing
2. Wrapping
3. Tweening
4. Panning
5. Zooming
6. Fractals

- **Morphing**: Morphing is an animation function that transforms an object's shape from one form to another. It's commonly used in movies, cartoons, advertisements, and computer games.
- The process involves three steps:
  - Initial and final images are added to the morphing application.
  - Key points on both images are selected for a smooth transition.
  - Key points of the first image transform to corresponding points of the second image.
- **Wrapping**: Wrapping function is Similar to morphing.
- wrapping distorts only the initial images so that it match the final images without fading occurs.

•**Tweening**: Also known as “inbetweening,”
•Tweening generates intermediate frames between initial and last final images. It’s popular in the film industry.

•**Panning**: In computer graphics, panning refers to moving a fixed-size window across a scene. The object appears to move in the opposite direction to the window’s movement.

- **Zooming:**
- **Zooming in:** When the window is made smaller around a fixed center, the object inside appears more enlarged.
- **Zooming out:** Increasing the window size makes the object appear smaller.

- **Fractals**: Fractal functions generate complex pictures using iteration.
- Iteration means the repetition of single formula again and again with slightly different value based on the previous iteration result.
- Results from previous iterations determine subsequent values, and displayed on the screen in the form of the display picture.

construction of animation sequence

- Constructing an animation sequence involves several essential steps.
- **Storyboard Layout**:
  - The **storyboard** serves as an outline for the animation.
  - It defines the motion sequence as a set of basic events that are to take place.
  - Think of it as a rough draft that outlines the key moments in your animation.
- **Object Definitions**:
  - Define the objects that will appear in your animation.
  - Specify their shapes, sizes, and any other relevant properties.
  - For example, if you're animating a character, define its body parts, clothing, and accessories.

- **Key-Frame Specifications**:
  - Keyframes represent significant moments in the animation.
  - These frames define specific positions, orientations, or other attributes of the objects.
  - Animators manually create these frames to guide the animation process.
  - For example, if you’re animating a bouncing ball, keyframes would mark the highest point of the bounce and the lowest point.
- **Generation of In-Between Frames**:
  - Once you have keyframes, the computer generates the **in-between frames** automatically.
  - These frames fill the gaps between keyframes, creating smooth motion.
  - The more in-between frames, the smoother the animation.
  - Algorithms interpolate the object’s position, rotation, and other properties between keyframes.

Key frame animation

•Keyframe animation, also known as **interpolation**, involves specifying certain frames (keyframes) in an animation sequence.
•These keyframes represent significant moments or positions in the animation.
•The computer then automatically generates the intermediate frames between these keyframes to create smooth motion.

•**How It Works:**
•An animator defines keyframes at specific time intervals.
•The computer interpolates between these keyframes to create the illusion of continuous motion.
•Keyframes can include information about position, rotation, scale, color, and other properties.

Types of Keyframe Animation

- **Linear Interpolation (LERP)**:
  - The simplest form of keyframe animation.
  - Linearly interpolates between keyframes.
  - Creates a straight path from one keyframe to the next.
- **Bezier Interpolation**:
  - Uses Bezier curves to create smoother transitions.
  - Allows for more control over the animation curve.
- **Spline Interpolation**:
  - Uses splines (curves) to connect keyframes.
  - Provides even more flexibility in shaping the animation path.

Applications:

- **Character Animation:**
  - Keyframe animation is widely used in character animation for movements like walking, running, and facial expressions.
- **Special Effects:**
  - Explosions, particle systems, and other dynamic effects rely on keyframe animation.
- **Camera Animation:**
  - Keyframes control camera movement, zoom, and rotation in 3D scenes.
- **Motion Graphics:**
  - Animated logos, text, and transitions often use keyframe animation.

Methods/Techniques of animation:

Frame by Frame (Traditional Method):

•Earlier, in traditional method, animation was done by hands because of the absence of the computer-aided drawing facilities.

•And, these traditional method required a lot of effort for even making a short video because of the fact that every second of animation requires 24 frames to process.

Procedural:

•In Procedural method, set of rules are used to animate the objects. Animator defines or specify the initial rules and procedure to process and later runs simulations.

•Many of the times rules or procedure are based on real world's physical rule which are shown by mathematical equations.

Behavioural:
According to this method/technique, to a certain extent the character or object specifies/determines it’s own actions which helps / allows the character to improve later, and in turn, it frees the animator in determining each and every details of the character’s motion.

Key Framing:
•A key frame in computer animation is a frame where we define changes in an animation.
•According to key framing, a storyboard requirement is must as the animator/artist draws the major frames (frames in which major/important changes can be made later) of animation from it.
•In key framing, character’s or object’s key position are the must and need to be defined by the animator, because the missing frames are filled in those key position via computer automatically.

Motion Capture:
This method of animation uses the live action/motion footage of a living human character which is recorded to the computer via video cameras and markers and later, that action or motion is used/applied to animate the character which gives the real feel to the viewers as if the real human character has been animated. Motion Capture is quite famous among the animators because of the fact that the human action or motion can be captured with relative ease.

Dynamics:
•In this method, simulations are used in order to produce a quite different sequence while maintaining the physical reality.
•Physic's laws are used in simulations to create the motion of pictures/characters.
•High level of interactivity can be achieved in this method, via the use of real-time simulations, where a real person performs the action or motions of a simulated character.

Motion control method in animation

Motion specification

There are several ways to specify the motion in any animation system.

The most general and straightforward method are

- Direct motion specification
- Goal directed system
- Kinematics and dynamics

Direct motion specification

- Explicit parameter are provided.
- Explicitly **rotation angle** are given to the object in any frame.
- Explicitly **translation vector** are given.
- **geometric transformation** are applied to transform coordinate position.

Example :

Bouncing Ball

Moving car change to another object

Advantages:-

- Easily and explicitly parameters are provided to any object
- Coordinate position are easily/applied to transform the object

Disadvantages:-

- No implicit parameters can be transform
- Acceleration of any object is not possible

Goal directed system

- Provide general term specification of the motion.
- **Abstractly** describe the action
    - Abstractly means expressing a quality or characteristic apart from any specific object
- These are referred as goal directed because they provide specific motion of parameter.

- **Example:** Walk, to run, to pickup

Kinematics and dynamics

Kinematics:

Study of motion (position, velocity & acceleration)

- Movement of an object from one place to another.
- Time intervals are measured such as min, sec, hour.
- These time intervals are observed between relative position and reference point.

Dynamics :

Time integration process which results from the one time frame effects the results on the next time frame.

- Time varying phenomena between motion , force & material properties.

Procedural animation

- Procedural animation is a fascinating technique used in computer graphics and game development.

- Instead of relying on predefined keyframes or motion capture, it generates dynamic and realistic movements for characters and objects using algorithms.

- Let’s dive into the world of procedural animations.

- **Traditional vs. Procedural Animations:**
- **Traditional animations** are static and created by artists.
- Each movement is crafted by hand or recorded using motion capture.
- These animations are predefined assets, and when a character needs to perform a different movement, a new animation is required.
- **Procedural animations**, on the other hand, generate movements dynamically.
- They can adapt to different situations and environments. Instead of relying solely on predefined assets, procedural animations use algorithms to create realistic behaviors.

- **Ragdoll Physics:**
- One of the simplest and effective ways to achieve procedural animations is through ragdoll physics. Here’s how it works:
- Create a humanoid body with limbs connected by joints that replicate real-world degrees of freedom.
- By relying on rigid body physics and joint constraints, simulate how a person would fall or interact with their surroundings.
- This approach not only saves resources (no need for a separate “dying animation”) but also allows for more realistic character movements.

- **Inverse Kinematics (IK):**
- Procedural animation often uses inverse kinematics as its underlying system. IK calculates joint positions based on desired end- effector positions (e.g., where a character’s hand should be).
- IK is widely used for tasks like character locomotion, reaching, and grabbing objects.

Physically Based Animations:

Physically based animations simulate real-world physics. For example:

Fluid dynamics: Instead of animating water by hand, simulate it using fluid dynamics equations.

Rigid body simulation: Game engines like Unity and Unreal use rigid body physics to create realistic interactions.

Applications:

Procedural animations find applications in various areas:

Character locomotion: Simulating walking, running, and other movements.

Environmental effects: Wind-blown leaves, swaying grass, and falling debris.

Creature animations: Simulating realistic animal movements.

Dynamic objects: Objects affected by forces (e.g., a swinging pendulum).

Stereoscopic Display Basics:

•Stereoscopic views does not produce three dimensional images, but it produce 3D effects by presenting different view to each eye of an observer so that it appears to have depth.

• To obtain this we first need to obtain two views of object generated from viewing direction corresponding to each eye.

Stereoscopic Display Basics:

- Stereoscopic displays create a perception of depth by presenting slightly different images to each eye. This mimics how our eyes naturally perceive the world in three dimensions.
- To achieve this effect, we need specialized hardware and software.
- Stereoscopic displays create a sense of depth by presenting slightly different images to each eye. This mimics human binocular vision.
- Commonly used display technologies in VR include **liquid crystal displays (LCDs)** and **organic light-emitting diodes (OLEDs).**

Hardware Technologies:

Display Devices:

Stereoscopic displays can be implemented using various devices:

- **Liquid Crystal Shutter Glasses**: These glasses alternate between blocking the left and right eye views in sync with the display refresh rate.
- **Polarized Glasses**: The display emits polarized light, and the glasses filter it for each eye.
- **Auto stereoscopic Displays**: These eliminate the need for glasses by projecting different images to different viewing angles.
- **Head-Mounted Displays (HMDs)**: VR headsets like Oculus Rift or HTC Vive provide immersive stereoscopic experiences.

3D Monitors: These monitors have built-in stereoscopic capabilities and support various 3D formats.

VR Headsets:

VR headsets incorporate stereoscopic displays. They utilize either LCDs or OLEDs to achieve the desired effect.

These headsets often include additional features like **gyroscopes**, **accelerometers**, and **cameras** for tracking head movements.

Depth Sensing Cameras:

For augmented reality (AR) and mixed reality (MR), depth-sensing cameras (e.g., **Microsoft Kinect**) capture the real-world scene and overlay virtual objects.

Graphics Cards and Drivers:

Modern graphics cards support stereoscopic rendering. They generate separate left-eye and right-eye views.

Stereoscopic drivers ensure synchronization between the graphics card and display.

3D Content Creation Tools:

Artists and developers use tools like **Blender**, **Maya**, or **Unity** to create stereoscopic content.

These tools allow precise control over stereoscopic parameters.

Software Technologies:

Stereoscopic Rendering:

Graphics engines (e.g., **OpenGL**, **DirectX**) render separate views for each eye.

Depth buffers ensure correct occlusion and depth perception.

Image-Based Rendering (IBR):

IBR techniques enhance depth perception in VR.

They use multiple images or viewpoints to create a more immersive experience.

SDKs and APIs:

Frameworks like **OpenVR**, **ARCore**, and **ARKit** provide APIs for developing stereoscopic applications.

These handle input, tracking, and rendering.

Challenges and Advancements:

- **Comfort**: Reducing eye strain during prolonged use.

- **Resolution**: Balancing resolution with stereoscopic effects.

- **Content Creation**: Simplifying the process for artists.

- **Holographic Displays**: Advancements like **light field displays** promise even more realistic 3D experiences.

Advancements in Computer Graphics

- Computer graphics have undergone significant advancements, impacting various domains such as design, art, education, entertainment, and scientific visualization.
- Historical development of graphical user interfaces, computer art techniques, presentation graphics, computer-aided design (CAD), educational applications, entertainment industry utilization, data visualization, and image processing have all contributed to the evolution of computer graphics

Management of Large-Scale Environments:

When dealing with vast virtual worlds or large-scale environments, several techniques come into play:

Level of Detail (LOD): Managing different levels of detail for objects based on their distance from the viewer. This ensures efficient rendering and minimizes computational load.

Culling Techniques: Discarding objects or parts of the scene that are not visible to the camera. Examples include frustum culling and occlusion culling.

Spatial Partitioning: Dividing the environment into smaller regions (e.g., octrees, BVHs) for efficient collision detection, visibility determination, and rendering.

Streaming and Paging: Loading and unloading parts of the environment dynamically to handle large datasets.

Dynamic Level Design: Procedurally generating or modifying parts of the environment based on gameplay or user interactions.
Parallelization: Utilizing multi-core CPUs or GPUs for parallel processing to improve performance.
GPU-Based Techniques: Leveraging the power of modern graphics hardware for real-time rendering and simulation.
Volumetric Rendering: Handling large-scale volumetric data (e.g., medical scans, fluid simulations) efficiently.
Terrain Rendering: Efficiently rendering large terrains with LOD and texture streaming.

Distributed Systems: Managing large-scale environments across multiple servers or nodes.
Real-Time Lighting and Shadows: Techniques like cascaded shadow maps, voxel-based global illumination, and screen-space reflections.
Virtual Reality (VR) and Augmented Reality (AR): Creating immersive experiences in large-scale virtual environments.

Real-Time Rendering:

Real-time rendering is crucial for interactive applications. Techniques include:

GPU-Based Ray Tracing: Real-time ray tracing for accurate lighting and reflections.

Deferred Rendering: Separating geometry and lighting calculations for efficiency.

Screen-Space Effects: Bloom, depth of field, motion blur, and ambient occlusion.

Temporal Anti-Aliasing: Improving image quality without sacrificing performance.

Dynamic Global Illumination: Realistic lighting effects in real time.