Computer Graphics

Unit 1 - Part2

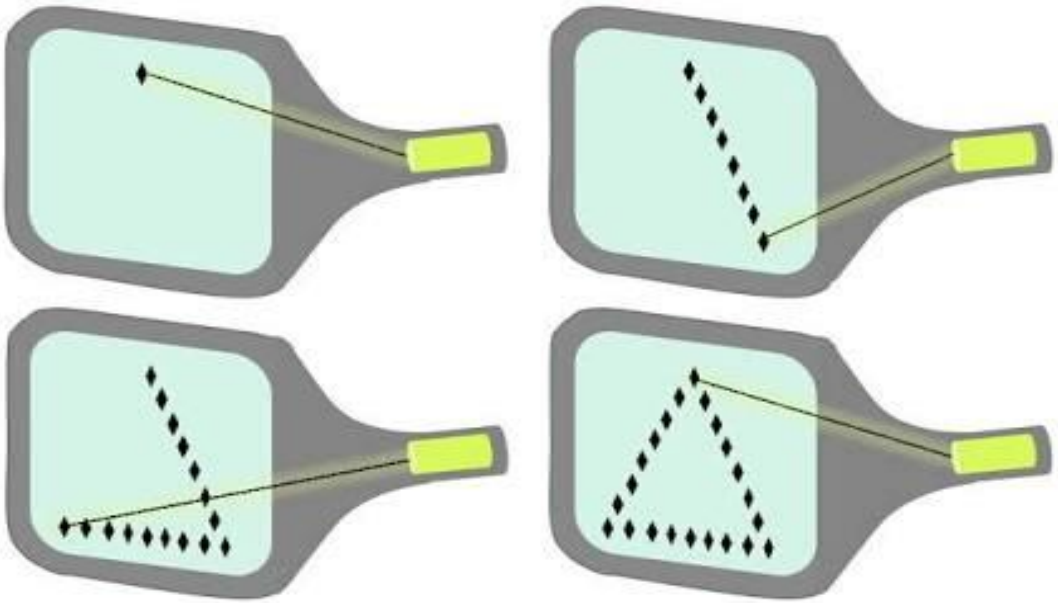
–By Manjula. S

Random scan display

- It uses an electron beam which operates like a pencil to create a line image on CRT screen.
- The picture is constructed out of a sequence of straight-line segments.
- Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its X and Y coordinates defines each point.
- After drawing the picture, the system cycles back the first line and design all the lines of the image.

Random scan display

- Random scan display are also known as Vector displays or Stroke-Writing displays or calligraphic displays.



Random Scan : A random scan system renders the compound lines of an object in any particular arrangement.

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Random scan display

Advantages:

- A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
- Produce smooth line drawings.
- High Resolution.

Disadvantages:

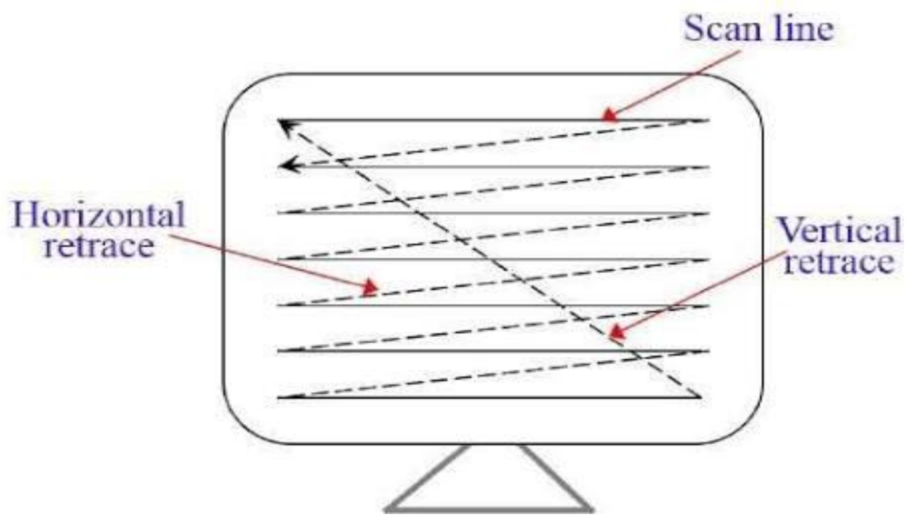
- Random scan monitors cannot display realistic shades scenes.

Raster Scan Display

- In a Raster scan systems, the electron beam is swept across the screen, one row at a time from top to bottom.
- As the electron beam moves across each row, the beam intensity is turned ON and Off to create a pattern of illuminated spots.
- 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.

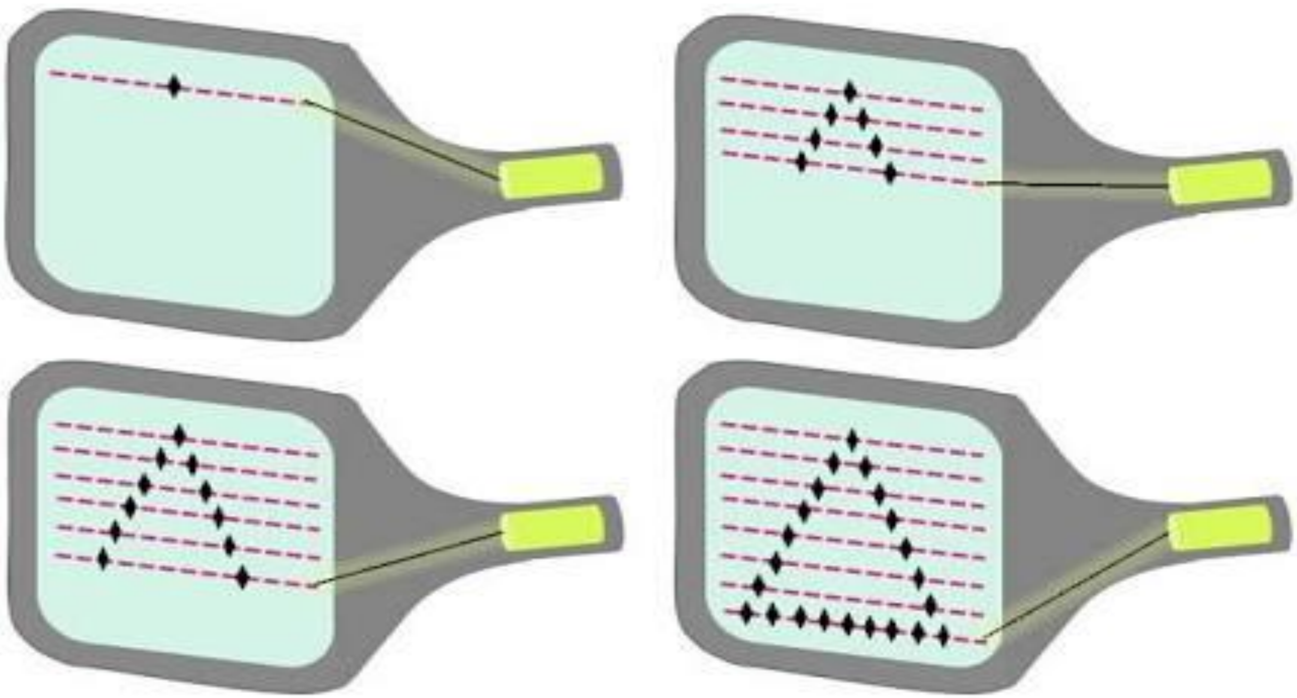
Raster Scan Display

- Stored intensity values are then retrieved from the refresh buffer and "**painted**" on the screen one row(scan line) at a time like,



- Each screen point is referred as a pixel(picture element).At end of each line, the electron beam returns to the left side of the screen to begin display the next scan line.

Raster Scan Display



Raster Scan: A raster scan system displays an item as a group of separate points along each screen line

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Raster Scan Display

Types of Scanning Or Travelling of beam in Raster Scan

- Interlaced Scanning
- Non Interlaced Scanning

Interlaced Scanning:

Here, each horizontal line of the screen is traced from top to bottom, due to which fading of display of object may occur. This problem can be solved by non-interlaced scanning. In this first cycle of all odd number lines are traced or visited by an electron beam, then in the next cycle,even number of lines are located .

Raster Scan Display

- **Non Interlaced Scanning**:
- Non-Interlaced display refresh rate of 30frames per second used. But it gives flickers. For interlaced display refresh rate of 60 frames per second is used.

Advantages of Raster Display:

1. Realistic images
2. Million Different colors to be generated.
3. Shadow scenes are possible.

Disadvantages:

1. Low Resolution
2. Expensive

Differentiate Between Random and Raster Scan Display

Random Scan	Raster scan
• It has high resolution. • It is more expensive. • Any Modification if needed is easy. • Solid pattern is tough to fill. • Refresh rate depends on resolution.	• Its resolution is low. • It is less expensive. • Modification is tough. • Solid pattern is easy to fill. • Refresh rate does not depend on the picture.

Generic flat-panel display

- The two outside plates contain parallel grids of wires that are oriented perpendicular to each other.
- The middle panel is different for the 3 types of displays.
- LED, LCD and Plasma panel.

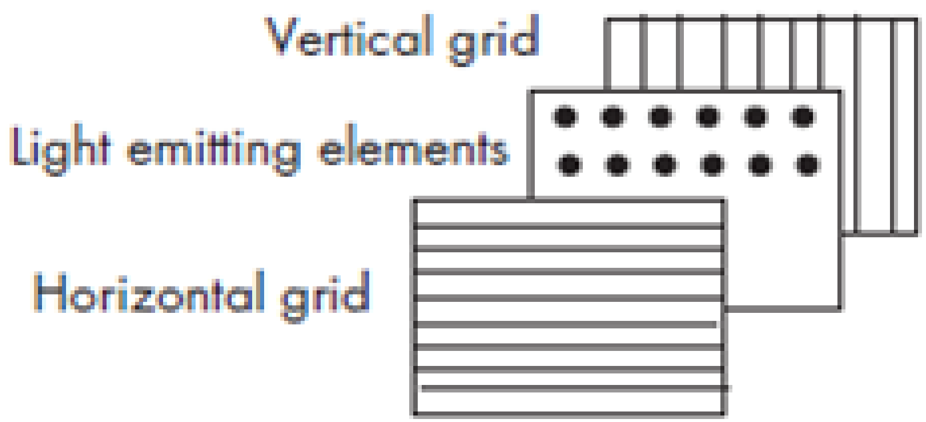

FIGURE 1.5 Generic flat-panel display.

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Generic flat-panel display

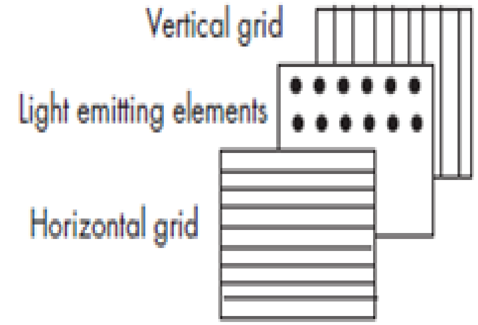

FIGURE 1.5 Generic flat-panel display.

- **LED display**
  The middle panel contains Light emitting Diodes which are turned ON and OFF by the electrical signals sent to the grid.
- **LCD display**
  Electrical field controls the polarization of liquid crystals in the middle panel.
- **Plasma**
  Uses voltage on the grids to energize gases embedded between the glass panels holding the grids. The energized gas becomes glowing plasma.

Objects and viewers

Basic entities that are part of any image formation process

1. **Objects**
2. **Viewers**

Objects

- Physical structure of the image.
- In graphics, we form objects by specifying the positions in space of various geometric primitives (lines, points, polygons).
- In most graphic systems, a set of vertices in space is sufficient to define most objects.

Viewers

- One who forms image of the object.
- Objects exist in real world and it is 3D. A viewer sees an object as image in 2D.
- Viewer can be Human, camera or digitizer.

Image formation

It is the process by which the specification of the object is combined with specification of the viewer to produce 2D image.

Imaging system

- Any **object** is always **3 dimensional**. **Image** is always **2 dimensional**.
- So an object from 3D is converted into image in 2D representation.
- To create an image we require
  - Object
  - Camera (viewer)
  - Light source

Imaging system

- Every imaging system must provide means of forming images from objects.
- To form an image, we must have someone viewing our objects (person, camera etc).
- **It is the viewer that forms the image of the objects**.
- In human visual system, image is formed at the back of the eye and in a camera, on a film plane.

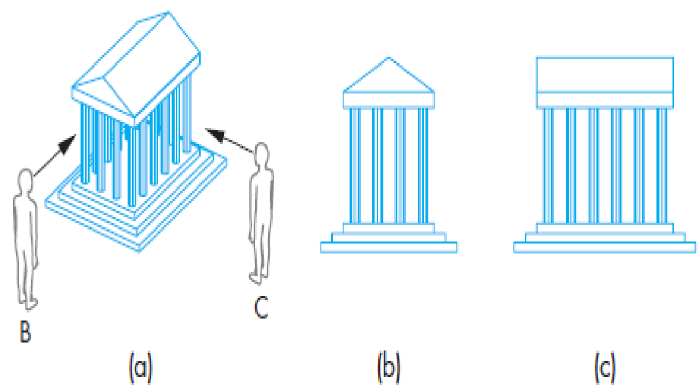

FIGURE 1.13 Image seen by three different viewers. (a) A's view. (b) B's view. (c) C's view.

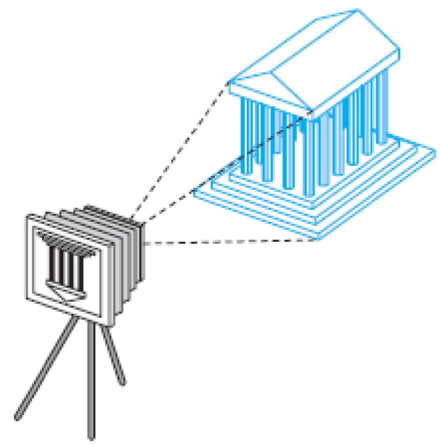

FIGURE 1.14 Camera system.

Elements of Image Formation

- Object
- Viewer
- Light source

Light and images

- Light is a form of electromagnetic radiation.
- EM energy travels as waves characterized by wavelengths or frequencies.
- EM spectrum includes radio waves, infrared(heat), and a portion that causes response in our visual system.

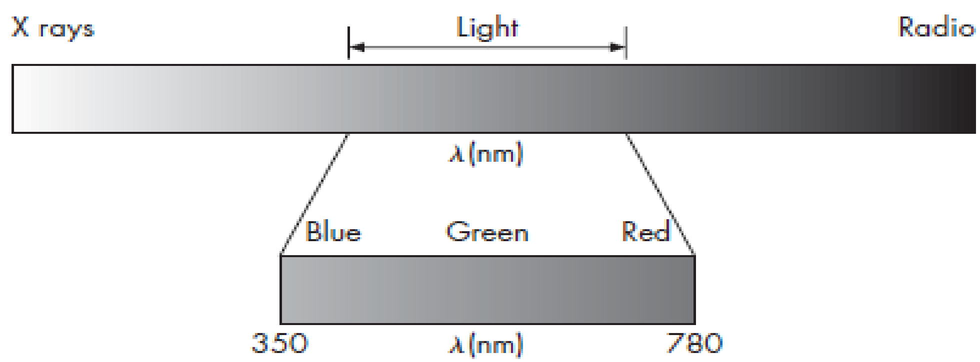

FIGURE 1.16 The electromagnetic spectrum.

Light and images

- Light from the source strikes various surfaces of the object, and a portion of the reflected light enters the camera through the lens.
- The interaction between light and the surfaces of the object determines how much light enters the camera.

Image formation models

- If source is visible from camera, some of the rays go directly from the source through the lens of the camera and strike film plane.
- Most rays go off to infinity. They contribute nothing to the image.
- Rays striking objects can interact in a variety of ways
  - If surface is mirror, depending on orientation of the surface – enters lens of camera and form images.
  - Other surfaces scatter light in all directions.
  - If surface is transparent, light ray from source can pass through it and may interact with other objects, enter the camera, or travel to infinity without striking other surface.

Image formation techniques

- Ray tracing
- Photon mapping
- Radiosity

Image formation techniques

- Ray tracing and photonmapping are image-formation techniques that are based on these ideas and that can form the basis for producing computer generated images.
- Ray-tracing idea is used to simulate physical effects as complex as we wish, as long as we are willing to carry out the requisite computing.
- Tracing rays can provide a close approximation to the physical world, it is usually not well suited for real-time computation.
- Other image formation is based on conservation of energy. In computer graphics it is radiosity.

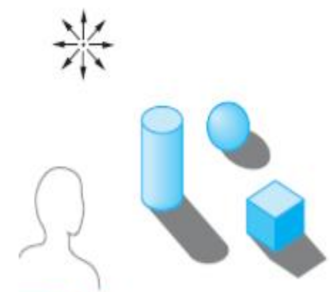

FIGURE 1.17 Scene with a single point light source.

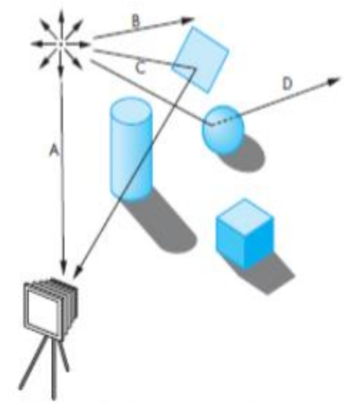

FIGURE 1.18 Ray interactions. Ray A enters camera directly. Ray B goes off to infinity. Ray C is reflected by a mirror. Ray D goes through a transparent sphere.

Imaging Systems

- Physical
- Synthetic

Two physical imaging systems

- Pin hole camera
- Human visual system

Pin hole camera

- A box with a small hole in the center of one side of the box.
- The film is placed inside the box on the side opposite the pinhole.
- Initially pin hole is covered.
- It is uncovered for a short while to expose the film.
- The hole is so small that only a single ray of light, originating from a point, can enter it.

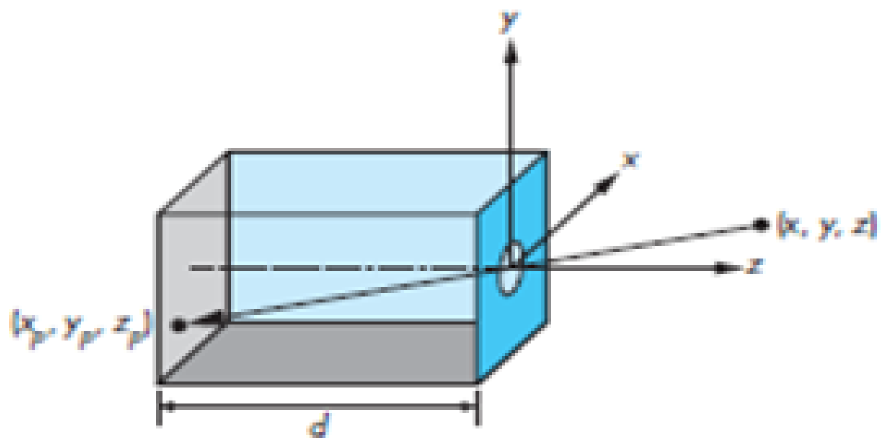

FIGURE 1.19 Pinhole camera.

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Pin hole camera

- Orient the camera along the z axis with the pinhole at the camera has length d.
- Assuming the pinhole allows only one ray of light from any point (x,y,z).
- The ray is clearly projected to the point (xp, yp,d).
- The point (xp, yp,d) is called as the projection of the point (x,y,z).

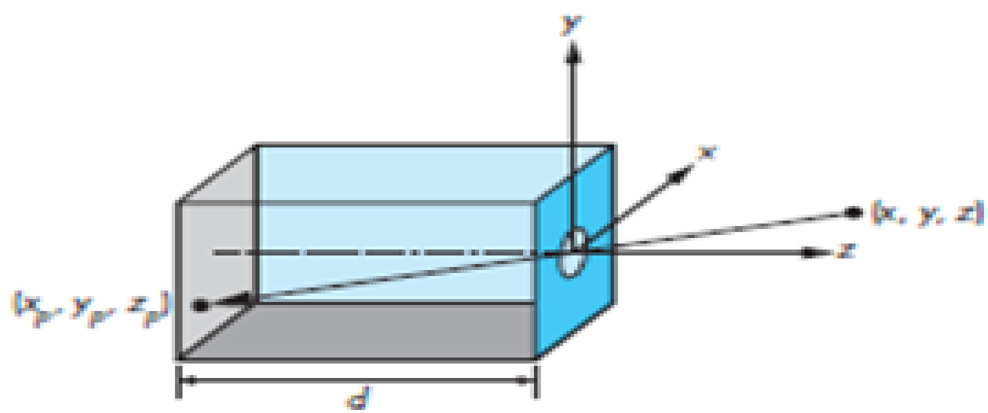

FIGURE 1.19 Pinhole camera.

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Pin hole camera

Side view

Calculate where the image of the point (x,y,z) is on the film plane : The two triangles are similar. So, yp / y = -d/z **Hence yp = – y/(z/d)**

Top view

We can calculate the x co ordinate of the image to be xp = -x/(z/d)

So

P is at x,y,d

P' is at xp, yp,-d

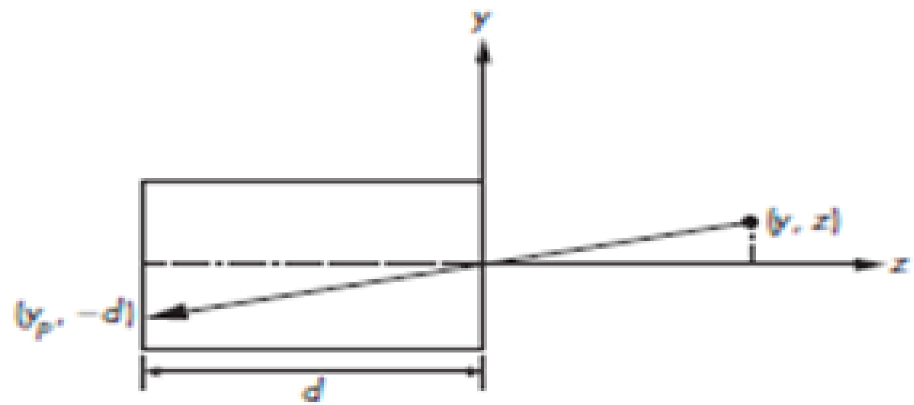

FIGURE 1.20 Side view of pinhole camera.

Pin hole camera

angle of view or field of the camera

- angle made by the largest object that our camera can image on its film plane.
- θ is calculated as θ =2 * tan-1 h/(2d)

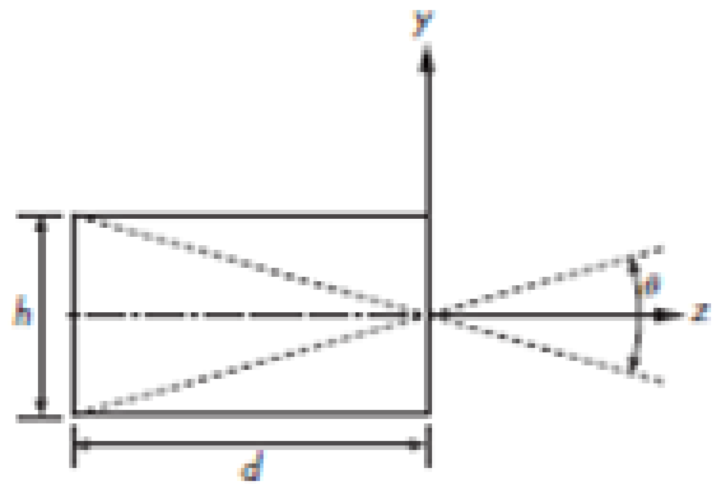

FIGURE 1.21 Angle of view.

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Pin hole camera

- Ideal pinhole camera has an infinite depth of field.
- Every point within its field of view is in focus, regardless of how far it is from the camera.

Disadvantages

- Pinhole is very small – admits only a single ray of light – almost no light enters the camera.
- The camera cannot be adjusted to have different angle of view. (ie, no zoom in or zoom out!)

Pin hole camera

- By replacing the pinhole with a lens, we solve the two problems of the pinhole camera.
  - Lens gather more light
  - By picking a lens with proper focal length, we can achieve any desired angle of view upto 1800
- Physical lenses do not have infinite depth of field; not all objects in front of the lens are in focus.

Human visual system

- Light enters the eye through the lens and cornea, a transparent structure that protects the eye.
- The iris opens and closes to adjust the amount of light entering the eye.
- The lens forms an image on a two-dimensional structure called the retina on the back of the eye.

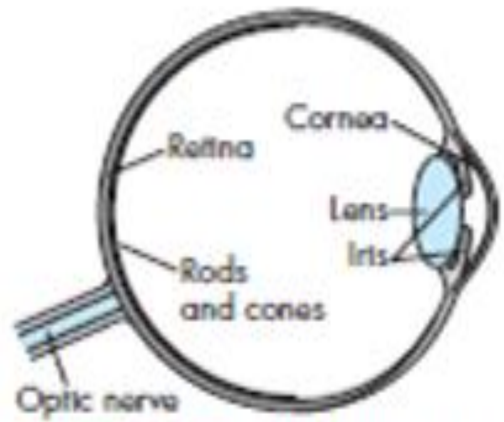

FIGURE 1.22 The human visual system.

Human visual system

Types of light sensors on retina

- Rods
- Cones

- Rods and cones are excited by EM energy in the range of 350 to 780nm.
- The sizes of the rods and cones, coupled with the optical properties of the lens and cornea, determine the resolution of our visual system.
- Resolution is a measure of what size objects we can see.

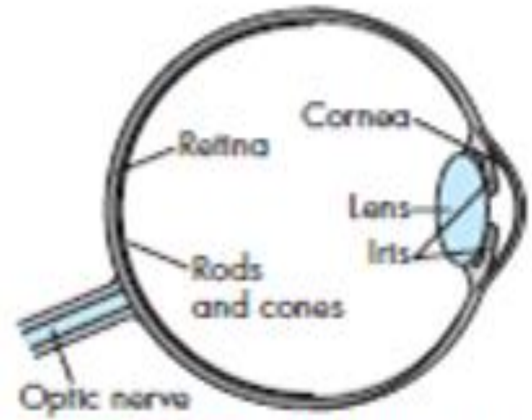

FIGURE 1.22 The human visual system.

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Human visual system

Rods:

- Low level light sensors responsible for **night vision** and **not color sensitive.**
- Single type of rod.

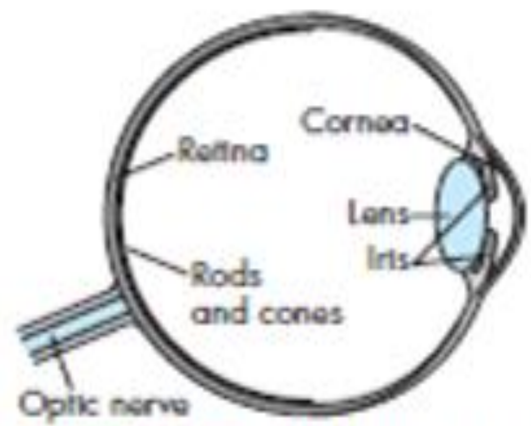


FIGURE 1.22 The human visual system.

Cones :

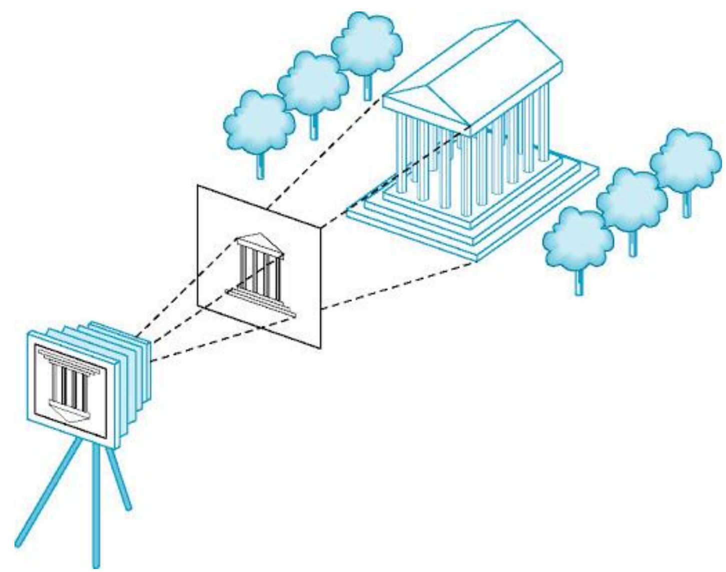
- Responsible for Color vision.
- 3 cones.

Human visual system

- The optic nerve is connected to the rods and cones in an extremely complex arrangement that has many of the characteristics of a sophisticated signal processor.
- Final processing is done in part of brain called as visual cortex, where high level functions like object recognition are carried out.
- The sensors in the human eye do not react uniformly to light energy at different wavelengths.
- We are most sensitive to green light, and least sensitive to red and blue.

The synthetic-camera model

- In computer graphics, we use a synthetic camera model to mimic the behaviour of a real camera.
- In computer graphics, we aren't using real film, so we can create a synthetic camera that puts the film plane in front of the pinhole - this keeps the projection rightside up and gets rid of all those minus signs.
- Synthetic camera model refers to process of creating a computer generated image similar to forming an image using an optical system.



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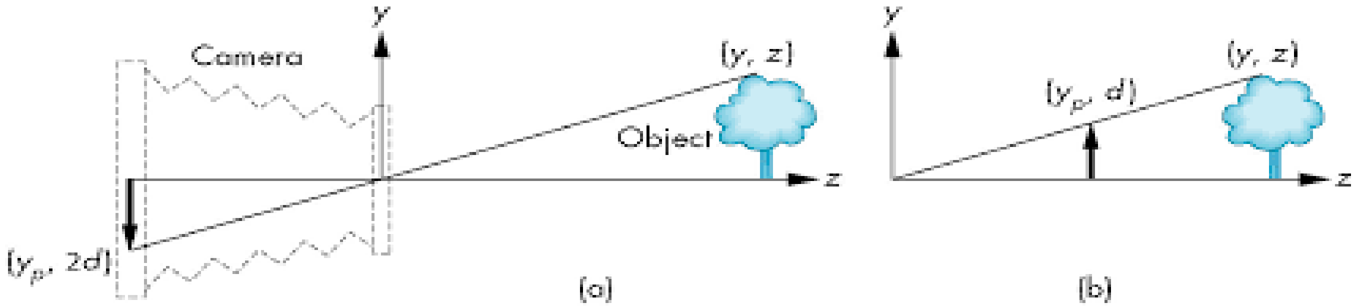
The synthetic-camera model

Principles:

1. Specification of object is independent of specific of viewer.
2. Within graphics library, there will be separate functions for specifying object and viewer.
3. We compute image using geometric calculations.

Equivalent views of image formation



In the synthetic camera model we avoid the inversion by placing the film plane, called the projection plane, in front of the lens.

(a) Image formed on back of the camera(as in a pinhole camera)

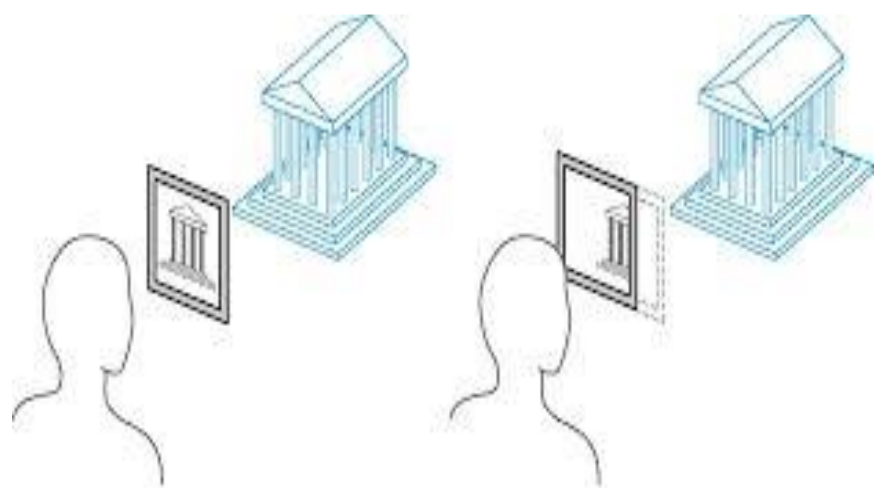
(b) Image plane moved in front of the camera

Imaging with the synthetic camera

- We draw **another plane** in front of lens and work in 3-dimensions.
- We find image of a point on the object on the virtual image plane by drawing a line, called **projector** – from the point to the center of the lens, called as **center of projection (COP)**.
- All projectors are rays emanating from the center of projection.
- The virtual image plane we have moved in front of the lens is called as the **projection plane**.
- The image of the point is located where the projector passes through the projection plane.

Clipping window

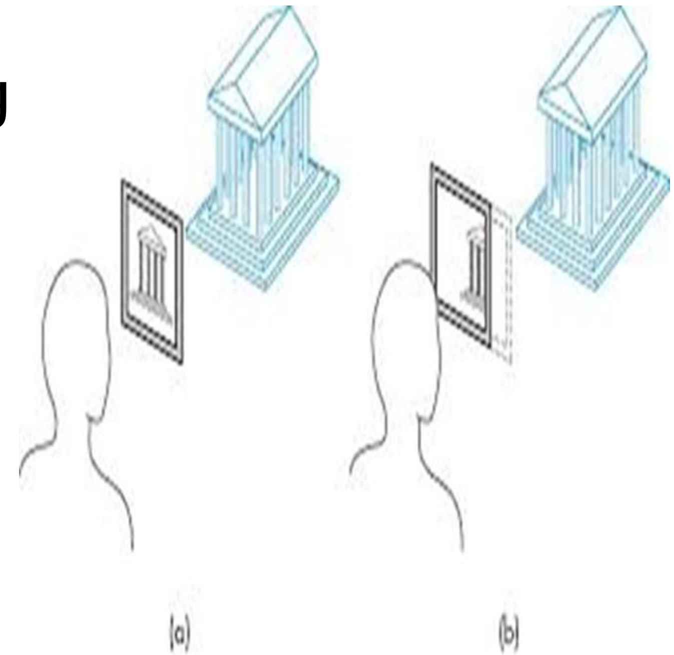
- We saw, not all objects can be imaged onto the pinhole camera's film plane.
- The angle of view expresses this limitation.
- This limitation is expressed in front by placing a clipping rectangle or clipping window, in the projection plane.



(a) (b)

Clipping window

- The clipping rectangle or clipping window determines the size of the image.
- This rectangle acts as a window, through which a viewer, located at the center of projection, sees the world.



- Given
  - Location of center of projection
  - Location and orientation of projection plane
  - Size of clipping rectangle

we can determine which objects will appear in the image.

The programmer's interface(PI/ API)

- The **interface** between an application program and a graphics system can be specified through a set of functions that resides in a graphics library.
- These specifications are called the **application programmer's interface.**

The programmer's interface

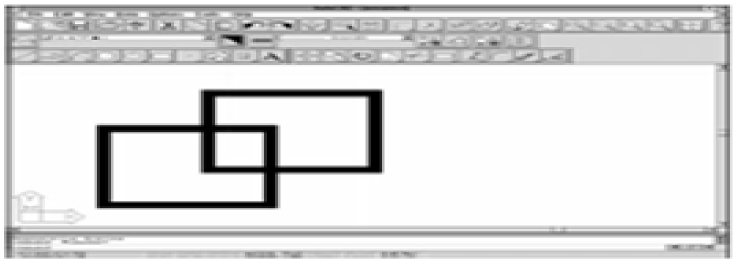


FIGURE 1.27 Interface for a painting program.

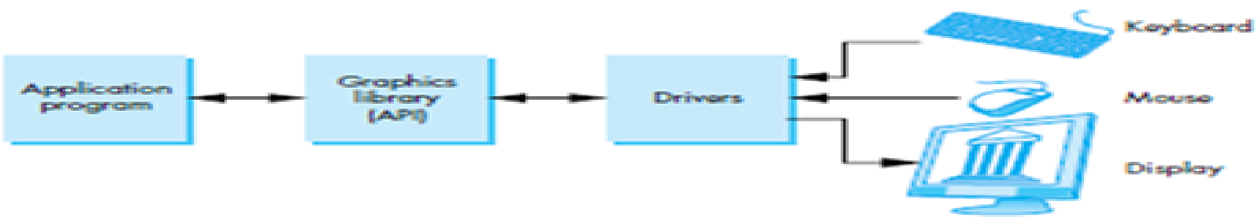


FIGURE 1.28 Application programmer's model of graphics system.

- The application programmer writes an application program using graphics functions supported by the API.
- The output of the API is given to the software drivers which convert the data to a form understood by the particular hardware.

Pen Plotter Model – 2D API

- Most early graphics systems were 2-D systems.
- 2D API is implemented by pen plotter model.
- Used in early graphics system.
- In this model, the user works on a 2D surface of some size. The pen is moved around, on this surface by leaving an image on the paper.
- Graphics functions used are **moveto(x, y)** and **lineto(x, y)**
- Advantage : simple to use.
- Disadvantage :not suitable for 3D applications.

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Pen Plotter Model

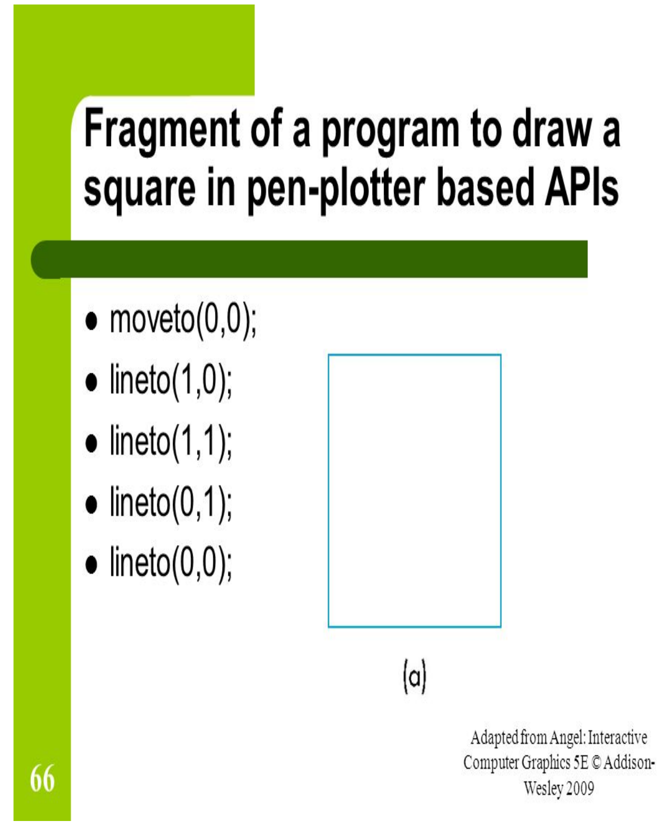
Two basic functions for drawing:

moveto(x, y) – pen up

Moves the pen to location x, y on the paper **without leaving a mark.**

lineto(x y) – pen down

Moves the pen to the location x, y and **draws a line** on the paper from the old location to the new location of the pen.



Thank You

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