INTRODUCTION TO COMPUTER GRAPHICS

Computer Graphics

- The computer is an information processing machine. It is a tool for storing, manipulating and correlating data.
- There are many ways to communicate the processed information to the user.
- The computer graphics is one of the most effective and commonly used ways to communicate the processed information to the user.
- It displays the information in the form of graphics objects such as pictures, charts, graphs and diagrams instead of simple text.
- Thus we can say that computer graphics makes it possible to express data in pictorial form.
- The picture or graphics object may be an engineering drawing, business graphs, architectural structures, a single frame from an animated movie or a machine parts illustrated for a service manual.

Advantages of Computer Graphics.

- A high quality graphics displays of personal computer provide one of the most natural means of communicating with a computer.
- It has an ability to show moving pictures, and thus it is possible to produce animations with computer graphics.
- With computer graphics use can also control the animation by adjusting the speed, the portion of the total scene in view, the geometric relationship of the objects in the scene to one another, the amount of detail shown and so on.
- The computer graphics also provides facility called update dynamics.
- With update dynamics it is possible to change the shape, color or other properties of the objects being viewed.

Applications of Computer Graphics

- **User interfaces:** It is now a well established fact that graphical interfaces provide an attractive and easy interaction between users and computers. The built-in graphics provided with user interfaces use visual control items such as buttons, menus, icons , scroll bar etc, which allows user to interact with computer only by mouse-click. Typing is necessary only to input text to be stored and manipulated.

- **Plotting of graphics and chart:** In industry, business, government, and educational organizations, computer graphics is most commonly used to create 2D and 3D graphs of mathematical, physical and economic functions in form of histograms, bars and pie-charts. These graphs and charts are very useful for decision making.

- **Computer-aided drafting and design:** The computer aided drafting uses graphics to design components and systems electrical, mechanical, electromechanical and electronic devices such as automobile bodies, structures of building, airplane, ships very large scale integrated chips, optical systems and computer networks.

- **Simulation and Animation:** Use of graphics in simulation makes mathematic models and mechanical systems more realistic and easy to study. The interactive graphics supported by animation software proved their use in production of animated movies and cartoons films.
- **Art and Commerce:** There is a lot of development in the tools provided by computer graphics. This allows user to create artistic pictures which express message and attract attentions. Such pictures are very useful in advertising.

- **Process Control:** By the use of computer now it is possible to control various processes in the industry from a remote control room. In such cases, process systems and processing parameters are shown on the computer with graphic symbols and identifications. This makes it easy for operator to monitor and control various processing parameters at a time.

- **Cartography:** Computer graphics is also used to represent geographic maps, weather maps, oceanographic charts, counter maps, population density maps and so on.

- **Image processing:** in computer graphics, a computer is used to create pictures. Image processing, on the other hands, applies techniques to modify or interpret existing picture such as photographs and scanned image.

- **Education and training:** computer graphics can be used to generate models of physical aids. Models of physical systems, physiological systems, population trends, or equipment, such as color coded diagram can help trainees to understand the operation of the system.

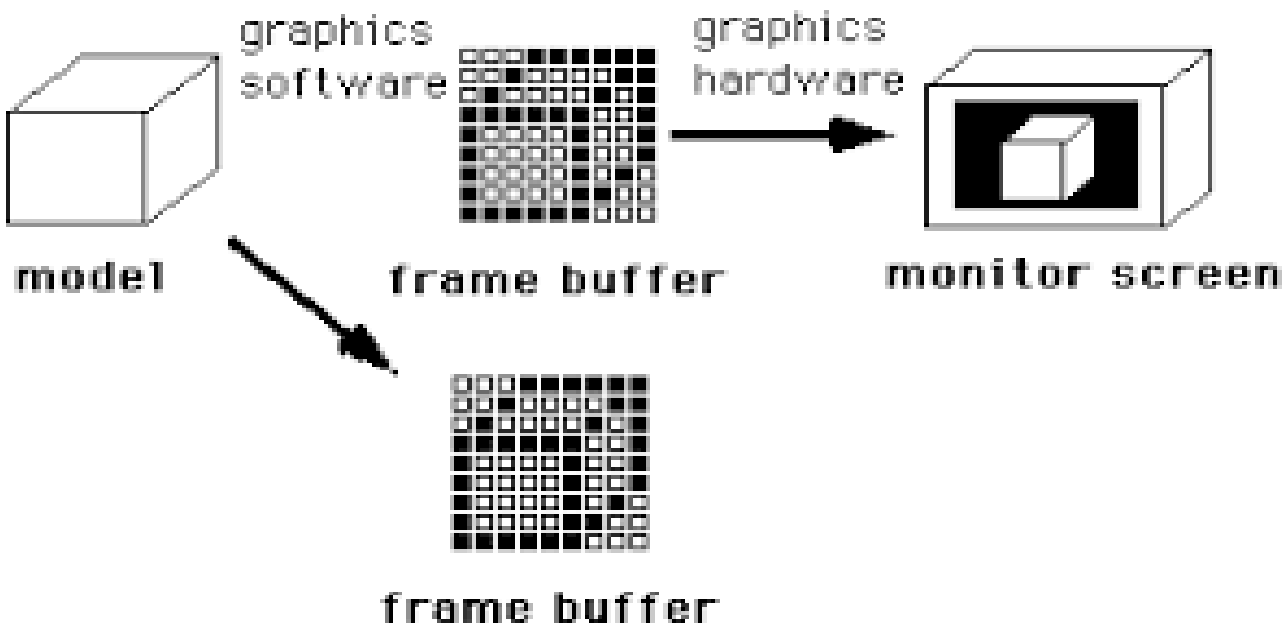
Pixel.

- In computer graphics, pictures or graphics objects are presented as a collection of discrete picture elements called pixels.
- The pixel is the smallest addressable screen element.
- It is the smallest piece of the display screen which we can control.
- The control is achieved by setting the intensity and color of the pixel which compose the screen.
- Each pixel on the graphics display does not represent mathematical point. Rather, it represents a region which theoretically can contain an infinite number of points.

Frame Buffer

- The frame buffer is the video memory that is used to hold or map the image that display on the screen.
- The portion of the memory reserved for holding the bitmapped image that is sent to the display device is called as frame buffer.
- Picture definition is stored in memory area called the refresh buffer or frame buffer.
- A frame buffer with one bit/pixel is called bitmap. A frame buffer with multiple bits/pixel is called pixmap.
- The information in the buffer typically consists of color values for every pixel(point that can be)displayed on the screen.

- A **framebuffer** (**frame buffer**,or sometimes **framestore**) is a portion of random-access memory (RAM) containing a bitmap that drives a video display.
- The information in the buffer typically consists of color values for every pixel to be shown on the display.
- Color values are commonly stored in 1 bit binary (monochrome), 4-bit palettized, 8-bit palettized, 16-bit high color and 24-bit true color formats.


graphics
software
graphics
hardware
model
frame buffer
monitor screen
frame buffer

Aspect Ratio

- Aspect ratio is the ratio of width to height.
- In **computer graphics**, the relative horizontal and vertical sizes.
- For example, if a **graphic** has an **aspect ratio** of 2:1, it means that the width is twice as large as the height.
- When resizing **graphics**, it is important to maintain the **aspect ratio** to avoid stretching the **graphic** out of proportion.
- The term is also used to describe the dimensions of a display resolution. For example, a resolution of 800x600 has an aspect ratio of 4:3.

Resolution

- Resolution Refers to the sharpness and clarity of an image.
- It refers to the number of dots on the screen.
- It is expressed as a pair of numbers that give the number of dots on a horizontal line and the number such vertical lines.
- Four resolutions are in common use today.

1. 640*480
2. 800*600
3. 1024*768
4. 1280*1024

- The term is most often used to describe monitors, printers, and bit-mapped graphic images.

Color Depth

- **Color depth(number of colors)** is determined by the number of bits assigned to hold color value.
- The number of bits used to hold a screen pixel. Also called "pixel depth" and "bit depth," the color depth is the maximum number of colors that can be displayed.

1. 1 bit-2 colors(black n white)
2. 4 bits-16 colors
3. 8 bits-256 colors
4. 16 bits -32 thousand colors
5. 24 bits- 16 million (high color)
6. 32 bits- latest(true color)

Refresh rate

- Refresh rate is nothing but the speed by which a particular dot on the screen is getting printed.
- The **refresh rate** is the number of times a display's image is repainted or refreshed per second.
- The **refresh rate** is expressed in hertz so a **refresh rate** of 75 means the image is refreshed 75 times in a second.
- The **refresh rate** for each display depends on the video card used.

Accelerator

- Accelerator chip is an integrated chip existing on the display adapter.
- It is used to draw readymade shapes like drawing lines and boxes, filling the color in the box, filling the background color and managing the mouse pointer.

Graphics Devices

1. **Interactive Devices**

i. Joystick

ii. Track ball

iii. Mouse

iv. Lightpen

v. Touch panels

vi. Tablets

Graphics input devices

Keyboards

- Keyboards are used as entering text strings. It is efficient devices for inputting such a non-graphics data as picture label.
- Cursor control key's & function keys are common features on general purpose keyboards.
- Many other application of key board which we are using daily used of computer graphics are commanding & controlling through keyboard etc.

Mouse

- Mouse is small size hand-held box used to position screen cursor.
- Wheel or roller or optical sensor is directing pointer on the according to movement of mouse.
- Three buttons are placed on the top of the mouse for signaling the execution of some operation.
- Now a day's more advance mouse is available which are very useful in graphics application for example Z mouse.

Trackball and Spaceball

- Trackball is ball that can be rotated with the finger or palm of the hand to produce cursor movement.

- Potentiometer attached to the ball, measure the amount and direction of rotation.
- They are often mounted on keyboard or Z mouse.
- Space ball provide six-degree of freedom i.e. three dimensional.
- In space ball strain gauges measure the amount of pressure applied to the space ball to provide input for spatial positioning and orientation as the ball is pushed or pulled in various directions.
- Space balls are used in 3D positioning and selection operations in virtual reality system, modeling, animation, CAD and other application.

Joysticks

- A joy stick consists of small vertical lever mounted on a base that is used to steer the screen cursor around.
- Most joy sticks selects screen positioning according to actual movement of stick (lever).
- Some joy sticks are works on pressure applied on sticks.
- Sometimes joy stick mounted on keyboard or sometimes used alone.
- Movement of the stick defines the movement of the cursor.
- In pressure sensitive stick pressure applied on stick decides movement of the cursor. This pressure is measured using strain gauge.
- This pressure sensitive joy sticks also called as isometric joy sticks and they are non movable sticks.

Digitizer

- Digitizer is common device for drawing painting or interactively selecting coordinates position on an object.
- One type of digitizers is graphics tablet which input two dimensional coordinates by activating hand cursor or stylus at selected position on a flat surface.
- Stylus is flat pencil shaped device that is pointed at the position on the tablet.

Image Scanner

- Image Scanner scan drawing, graph, color, & black and white photos or text and can stored for computer processing by passing an optical scanning mechanism over the information to be stored.
- Once we have internal representation of a picture we can apply transformation.
- We can also apply various image processing methods to modify the picture.
- For scanned text we can apply modification operation.

- **Data Generating Devices**
- **Scanners**

There are generally three types of scanners:

I. Flat scanners
II. Hand scanners
III. Sheet-fed scanners

- **Digitizers**

Display Devices

- There are several hardware devices which may be used to display images.

1. Video Display Devices:

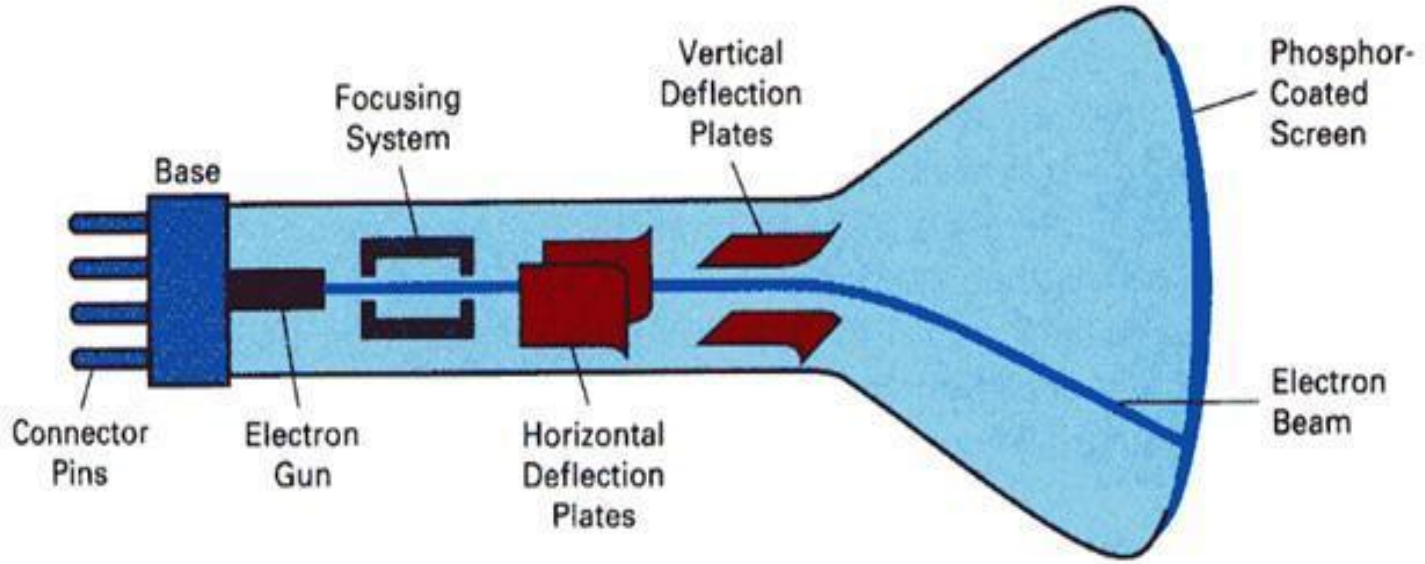
   There are two types of video monitors-

   i. Monochrome display monitor

   ii. Color display monitor

- Let us first see the Monochrome display monitor(Black n White).
- Display devices are also known as output devices.
- Most commonly used output device in a graphics system is video monitor.

Monochrome display monitor



- It is an evacuated glass tube.
- An electron gun at the rear of the tube produce a beam of electrons which is directed towards the screen of the tube by a high voltage typically 15000 to 20000 volts
- Inner side screen is coated with phosphor substance which gives light when it is stroked bye electrons.
- Control grid controls velocity of electrons before they hit the phosphor.
- The control grid voltage determines how many electrons are actually in the electron beam. The negative the control voltage is the fewer the electrons that pass through the grid.
- Thus control grid controls Intensity of the spot where beam strikes the screen.
- The focusing system concentrates the electron beam so it converges to small point when hits the phosphor coating.
- Deflection system directs beam which decides the point where beam strikes the screen.
- Deflection system of the CRT consists of two pairs of parallel plates which are vertical and horizontal deflection plates.
- Voltage applied to vertical and horizontal deflection plates is control vertical and horizontal deflection respectively.

- There are two techniques used for producing images on the CRT screen.

1. Vector scan/Random scan display
2. Raster scan display

Difference between random scan and raster scan

Base of Difference	Raster Scan System	Random Scan System
Electron Beam	The electron beam is swept across the screen, one row at a time, from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn.
Resolution	Its resolution is poor because raster system in contrast produces zigzag lines that are plotted as discrete point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic Display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and color pattern.	These systems are designed for line-drawing and can't display realistic shaded scenes.
Draw an Image	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

- **Advantages:**

a) They operate at any resolution, geometry and aspect ratio without the need for rescaling the image.

b) CRTs run at the highest pixel resolutions generally available.

c) Produce a very dark black and the highest contrast levels normally available. Suitable for use even in dimly lit or dark environments.

d) CRTs produce the very best color and gray-scale and are the reference standard for all professional calibrations. They have a perfectly smooth gray-scale with an infinite number of intensity levels. Other display technologies are expected to reproduce the natural power-law Gamma curve of a CRT, but can only do so approximately.

e) CRTs have fast response times and no motion artifacts. Best for rapidly moving or changing images.

f) CRTs are less expensive than comparable displays using other display technologies.

Color Display Monitor

Color CRT monitors

- A CRT monitors displays color pictures by using a combination of phosphors that emit different colored light.
- It produces range of colors by combining the light emitted by different phosphors.
- There are two basic techniques for color display:
    1. Beam-penetration technique
    2. Shadow-mask technique

Beam-penetration technique

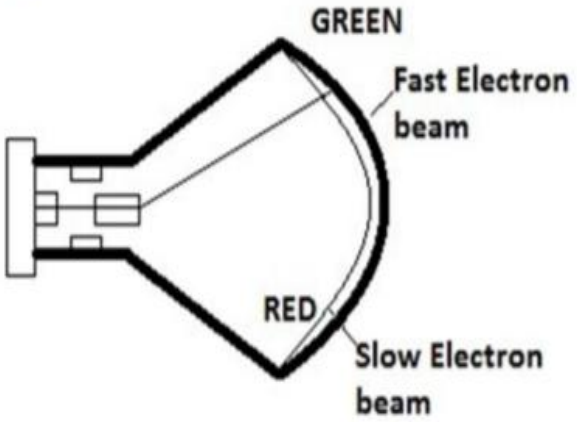


Fig. 1.5: - Beam-penetration CRT

- This technique is used with random scan monitors.
- In this technique inside of CRT coated with two phosphor layers usually red and green. The outer layer of red and inner layer of green phosphor.
- The color depends on how far the electron beam penetrates into the phosphor layer.
- A beam of fast electron penetrates more and excites inner green layer while slow electron excites outer red layer.
- At intermediate beam speed we can produce combination of red and green lights which emit additional two colors orange and yellow.
- The beam acceleration voltage controls the speed of the electrons and hence color of pixel.
- It is a low cost technique to produce color in random scan monitors.
- It can display only four colors.
- Quality of picture is not good compared to other techniques.

Shadow-mask technique

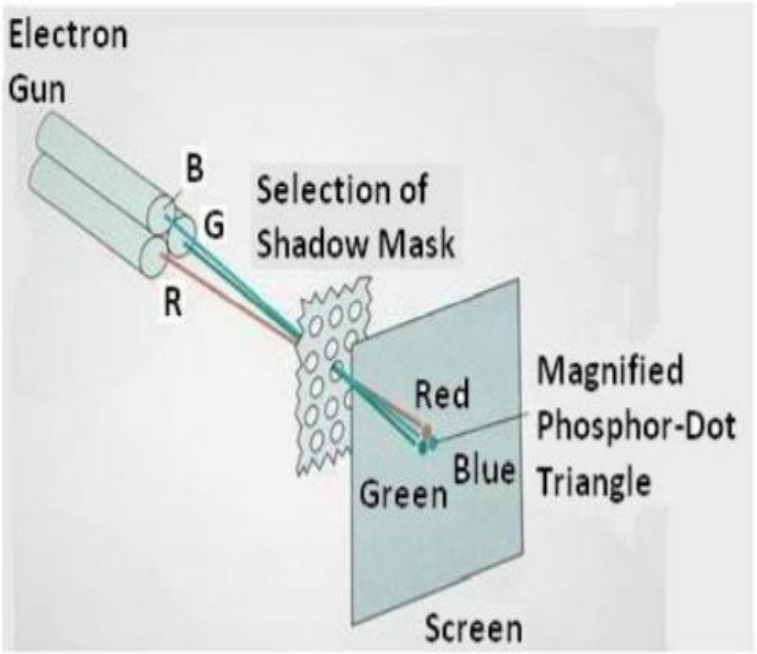


Fig. 1.6: - Shadow-mask CRT.

- It produces wide range of colors as compared to beam-penetration technique.
- This technique is generally used in raster scan displays. Including color TV.
- In this technique CRT has three phosphor color dots at each pixel position. One dot for red, one for green and one for blue light. This is commonly known as **Dot Triangle.**
- Here in CRT there are three electron guns present, one for each color dot. And a shadow mask grid just behind the phosphor coated screen.
- The shadow mask grid consists of series of holes aligned with the phosphor dot pattern.
- Three electron beams are deflected and focused as a group onto the shadow mask and when they pass through a hole they excite a dot triangle.
- In dot triangle three phosphor dots are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.
- A dot triangle when activated appears as a small dot on the screen which has color of combination of three small dots in the dot triangle.
- By changing the intensity of the three electron beams we can obtain different colors in the shadow mask CRT.

Direct-view storage tubes (DVST)

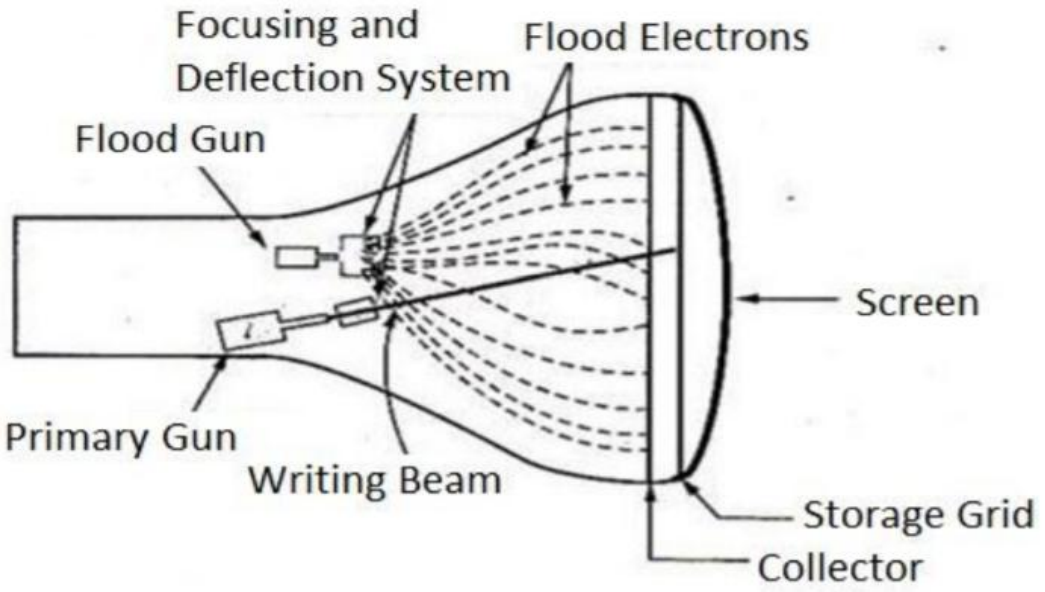


Fig. 1.7: - Direct-view storage tube.

- In raster scan display we do refreshing of the screen to maintain a screen image.
- DVST gives alternative method for maintaining the screen image.
- DVST uses the storage grid which stores the picture information as a charge distribution just behind the phosphor coated screen.
- DVST consists two electron guns a primary gun and a flood gun.
- A primary gun stores the picture pattern and the flood gun maintains the picture display.
- A primary gun emits high speed electrons which strike on the storage grid to draw the picture pattern.
- As electron beam strikes on the storage grid with high speed, it knocks out electrons from the storage grid keeping the net positive charge.
- The knocked out electrons are attracted towards the collector.
- The net positive charge on the storage grid is nothing but the picture pattern.
- The continuous low speed electrons from flood gun pass through the control grid and are attracted to the positive charged area of the storage grid.

Introduction to OpenGL -

- **OpenGL is a software interface that allows the programmer to create 2D and 3D graphics images.**
- **OpenGL is both a standard API and the implementation of that API.**
- **OpenGL is independent of the hardware, operating, and windowing systems in use.**
- **The fact that it is windowing-system independent, makes it portable.**
- **OpenGL program must interface with the windowing system of the platform where the graphics are to be displayed.**

- **OpenGL's rendering commands, however are "primitive". You can tell the program to draw points, lines, and polygons, and you have to build more complex entities upon these.**
- **There are no special-purpose functions that you can call to create graphs, contour plots, maps, or any of the other elements we are used to getting from "old standby programs".**

Features in OpenGL

- 3D Transformations

  - Rotations, scaling, translation, perspective

- Colour models

  - Values: R, G, B, alpha.

- Lighting

  - Flat shading, Gouraud shading, Phong shading

- Rendering

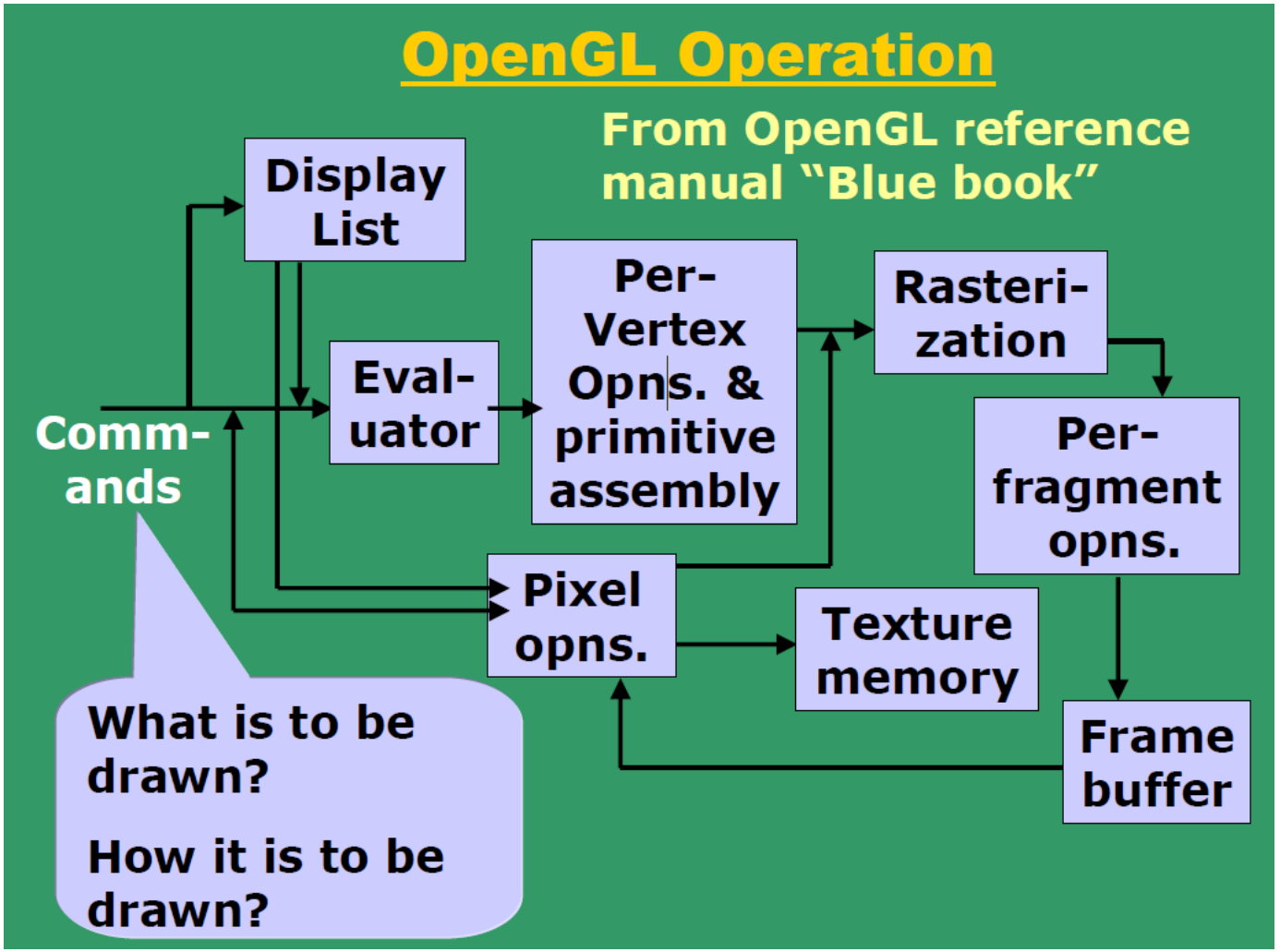
  -Texture mapping

- Modeling

  - non-uniform rational B-spline (NURB) curves, surfaces

OpenGL Operation

From OpenGL reference manual "Blue book"



- **Commands:** what is to be drawn? How it is to be drawn?
- **Display list:** Can accumulate some commands in a display list for processing at a later time (Batch mode). Or can proceed immediately through the pipeline.
- **Evaluators:** Provides an efficient means for approximating curve and surface geometry by evaluating polynomial commands of input values.
- **Per-Vertex opns. & Primitive assembly**: Process geometric primitives -points, line segments, and polygons as vertices and are transformed, lit, and clipped to the viewport in preparation for the next stage.

- **Rasterization:** Produces a series of frame buffer addresses and associated values using a two-dimensional description of a point, line segment, or polygon.
- **Perfragment oprations:** Z-buffering, and blending of incoming pixel colors with stored colors, and masking and other logical operations on pixel values.
- **Pixel oprations:** Input data can be in the form of pixels (image for texture mapping) is processed in the pixel operations stage**.**