COMPUTER GRAPHICS - introduction

UNIT -1

Applications of Computer Graphics and Multimedia

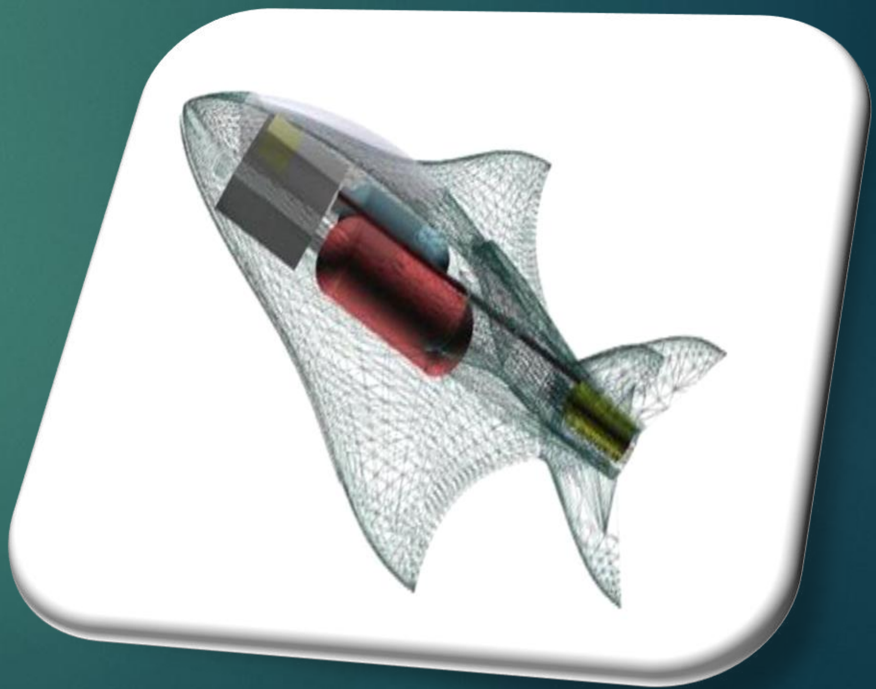
- Computer-Aided Design (CAD)
- Presentation Graphics
- Computer Art
- Entertainment
- Education and Training
- Visualization
- Image processing
- Graphical User Interfaces

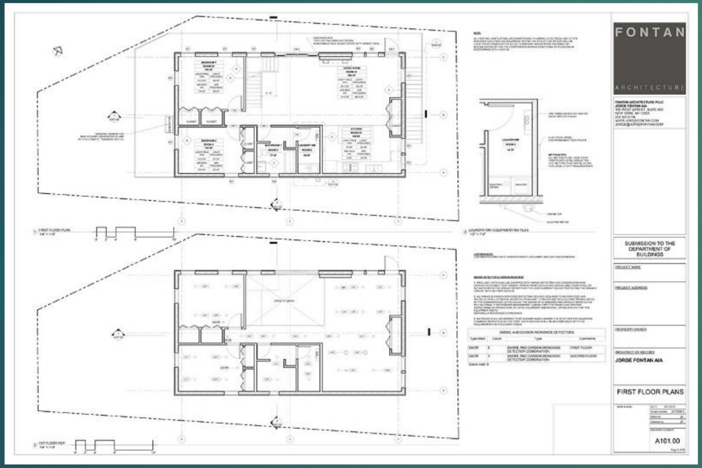
Computer Aided Design

- For engineering and architectural systems, a major use of computer graphics is in design processes.
- CAD methods are used in the design of buildings, automobiles, aircraft, watercraft, space craft, computers, textiles and many other products.
- For some design applications, objects are first displayed in a wireframe out-line form, that shows the overall shape and internal features of objects.

- Wireframe display for Automobile

- Wireframe display for Aircraft

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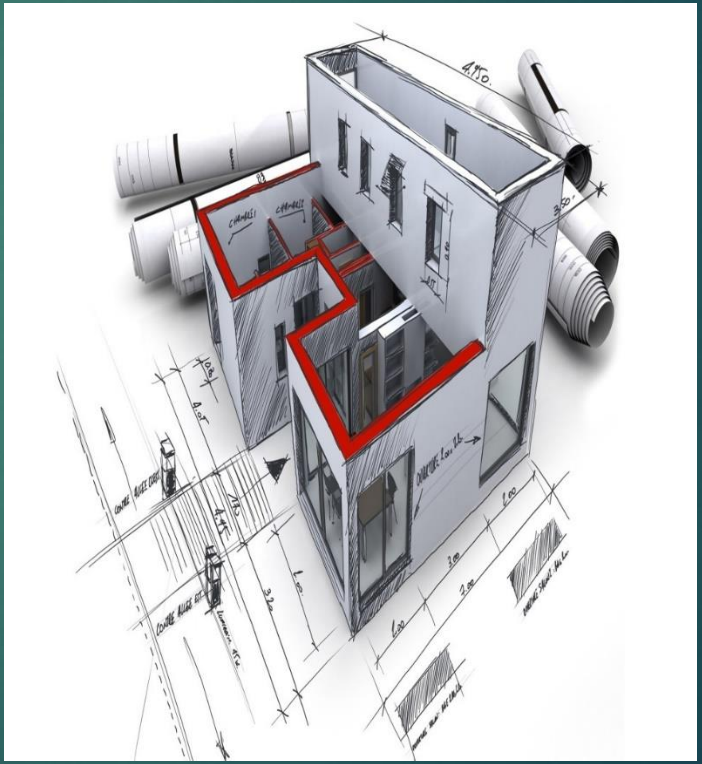

- Circuits and networks for communications, water supply, or other utilities are constructed with repeated placement of a few graphical shapes.
- Standard shapes for electrical, electronic, and logic circuits are often supplied by the design package.
- Facilities are provided to designer to try out alternate circuit schematics for minimizing the number of components or the space required for the system.
- Animations are often used in CAD applications.
- Software packages for CAD applications typically provide the designer with a multi-window environment.
- Almost in every branch of engineering, the graphics are used in different fashion.

Presentation Graphics

- Presentation graphics are used to produce illustrations for reports or to generate slides or transparencies for use with projectors.
- They are commonly used to summarize financial, statistical, mathematical, scientific, and economic data for research reports, managerial reports, consumer information bulletins, and other types of reports.
- Examples are bar charts, line graphs, surface graphs, pie charts, and other displays showing relationships between multiple parameters.

Computer Arts

- Computer graphics methods are widely used in both fine art and commercial art applications.
- Artists use special purpose hardware, software packages or programs that allow him/her to paint pictures on the screen of a video monitor.
- The picture is usually painted electronically on a graphics tablet (digitizer) using a stylus, which can simulate different brush strokes, brush widths, and colors.
- The stylus translates changing hand pressure into variable line widths, brush sizes, and color gradations.
- Computer arts are also used in commercial art for logos and other designs, page layouts combining text and graphics, TV advertising, and other areas.
- ***Morphing*** is a common graphics method employed in many commercials, where one object is transformed into another.

Art design using paint brush

Graphics design using mathematical functions

Entertainment

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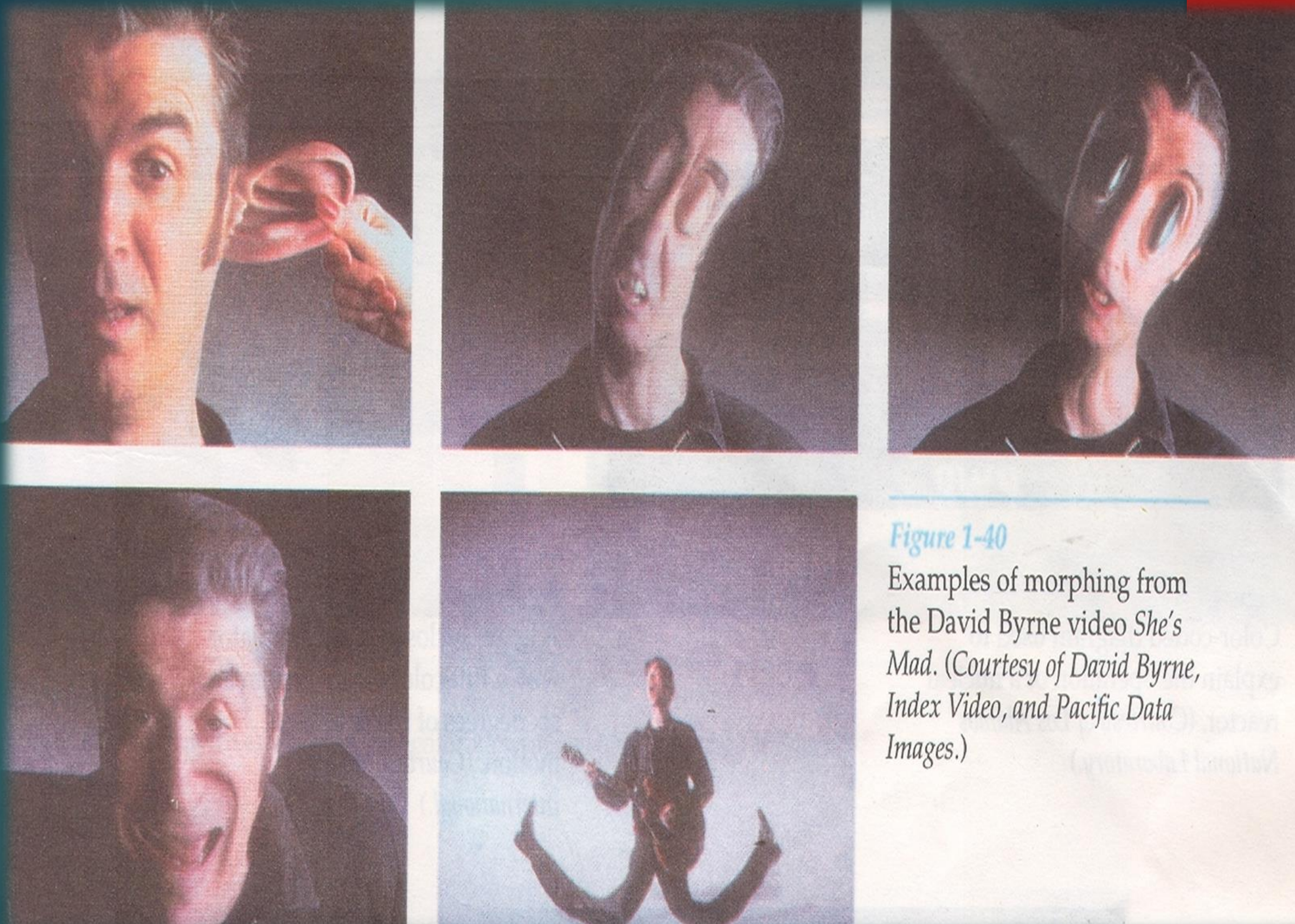

Figure 1-40
Examples of morphing from the David Byrne video *She's Mad*. (*Courtesy of David Byrne, Index Video, and Pacific Data Images.*)

Education and Training

- Computer-generated models of physical, financial, and economic systems are often used as educational aids.
- Models can help trainees to understand the operation of the system.
- For some training applications, special systems are designed. For example, the simulators for practice session or training of ship captains, aircraft pilots, heavy-equipment operators, and air traffic control personnel.
- Most simulators provide graphics screens for visual operation.


DRIVEWISE
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Visualization

- Scientists, business analysts or some people who often need to analyze large amounts of information or to study the behavior of certain process are benefited by graphics.
- Numerical simulations carried out on supercomputers frequently produce data files containing thousands and even millions of data values.
- Scanning these large sets of numbers to determine trends and relationships is a tedious and ineffective process. But if the data are converted to a visual form, the trends and patterns are often immediately apparent.

Image Processing

- In computer graphics, a computer is used to create a picture. Image processing, on the other hand, applies techniques to modify or interpret existing pictures, such as photographs and TV scans.
- Principal applications of image processing are

1. Improving picture quality and
2. Machine perception of visual information

Graphical User Interfaces

- Menus, icons, windows etc.

Graphics Software

- There are two general classifications of graphics software: (i) General programming packages and (ii) Special-purpose application packages.

1. General programming package provides an extensive set of graphics functions that can be used in a high-level programming language, such as C or FORTRAN. Example of a general graphics programming package is the GL(Graphics Library).
2. Application graphics packages are designed for nonprogrammers, so that users can generate displays without worrying about how graphics operations work. Examples of such applications packages are the artist's painting programs, CAD systems, medical applications etc.

Software Standards

1.Graphical Kernel System (GKS)

- **GKS** was the first ISO standard for low-level computer graphics, introduced in 1977.
- GKS provides a set of drawing features for two-dimensional vector graphics suitable for charting and similar duties.
- The calls are designed to be portable across different programming languages, graphics devices and hardware, so that applications written to use GKS will be readily portable to many platforms and devices.
- Next version of GKS supported 3D pictures.
- A descendant of GKS was PHIGS.

2.PHIGS

- **PHIGS** (**Programmer's Hierarchical Interactive Graphics System**) is an API standard for rendering 3D computer graphics.
- PHIGS was designed in the 1980s, inheriting many of its ideas from the Graphical Kernel System of the late 1970s.
- It include some extra features like color specification, picture manipulation, surface rendering etc.
- It provide basic graphics function, but it does not specify any standard method to interface with devices.
- It does not support any method to store and transmission of images.
- Next version is PHIGS+. It include 3D surface shading capability.

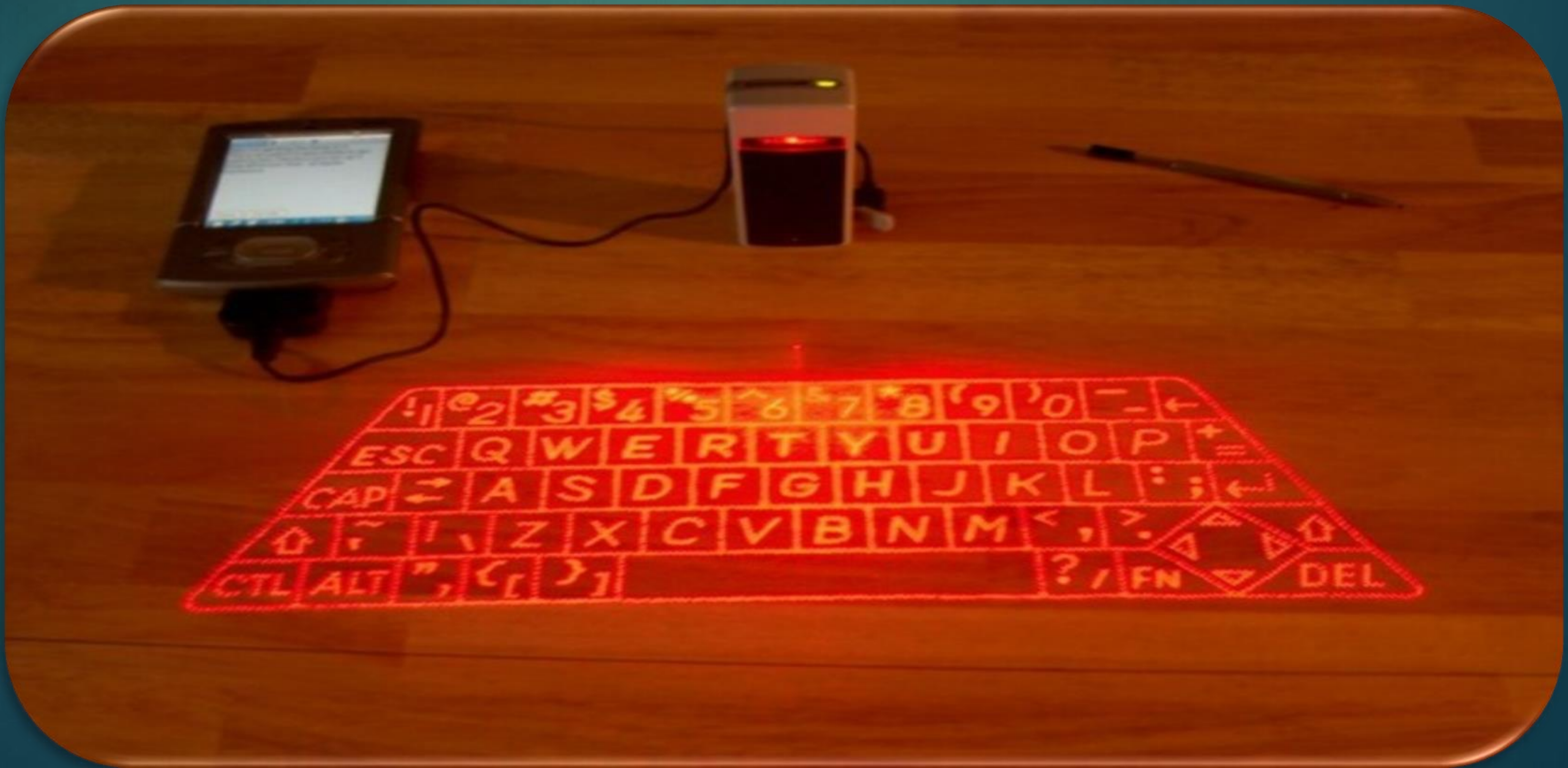
- To overcome the limitations of PHIGS, separate standards have been developed.
- Standardization for device interface methods is given in the ***Computer Graphics Interface (CGI)*** system and the ***Computer Graphics Metafile (CGM)*** system specifies standards for archiving and transporting pictures.

3. OpenGL

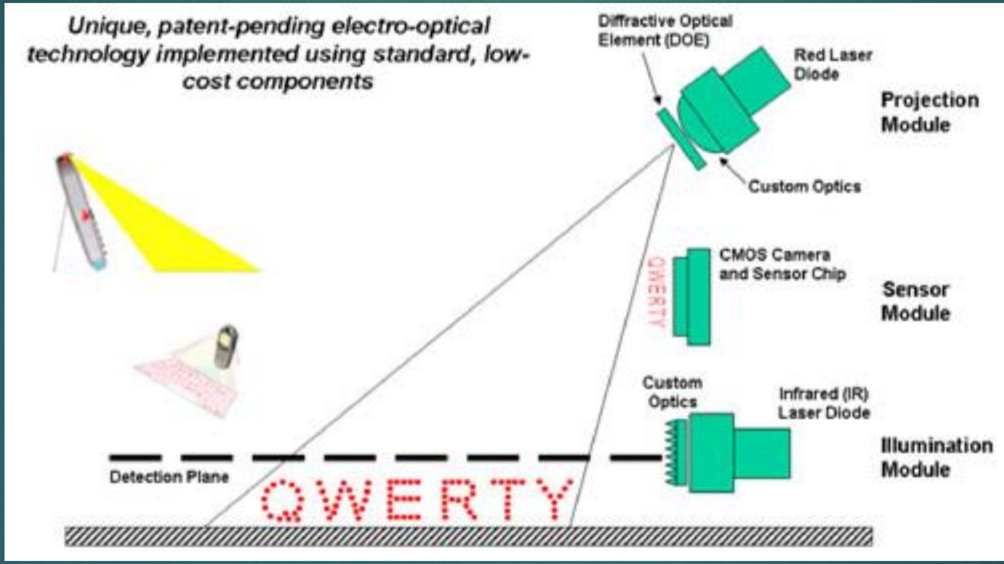
- **OpenGL** (**Open** **G**raphics **L**ibrary) is a standard specification defining a cross-language, cross-platform API for writing applications that produce 2D and 3D computer graphics.
- The interface consists of over 250 different function calls which can be used to draw complex three-dimensional scenes from simple primitives.
- OpenGL's basic operation is to accept primitives such as points, lines and polygons, and convert them into pixels.
- OpenGL's "low-level" API allowed the programmer to make dramatic improvements in rendering performance by first examining the data on the CPU-side before trying to send it over the bus to the graphics engine. For instance, the programmer could "cull" the objects by examining which objects were actually visible in the scene, and sending only those objects that would actually end up on the screen. This was kept private in PHIGS, making it much more difficult to tune performance.

Input Devices

1. Keyboard: used for inputting non-graphic data.
2. Virtual Keyboard:



Technology Behind Virtual Keyboard



- **Step 1: Template creation (Projection Module)**
  A template of the desired interface is projected onto the adjacent interface surface. The template is produced by illuminating a specially designed, highly efficient holographic optical element with a red diode laser. Note: the template serves only as a reference for the user and is not involved in the detection process. In a fixed environment, the template can just as easily be printed onto the interface surface.

  Step 2: Reference plane illumination (Micro-illumination ModuleTM)
  An infra-red plane of light is generated just above, and parallel to, the interface surface. This light is invisible to the user and hovers a few millimeters above the surface. When the user touches a key position on the interface surface light is reflected from this plane in the vicinity of the key and directed towards the sensor module.

  Step 3: Map reflection coordinates (Sensor Module)
  Reflected light from user interactions with the interface surface is passed through an infra-red filter and imaged on to a CMOS(Complementary Metal-Oxide Semiconductor) image sensor in the sensor module. Custom hardware embedded in the sensor chip (the Virtual Interface Processing CoreTM) then makes a real-time determination of the location of the reflected light. The processing core can track multiple reflection events simultaneously and can thus support both multiple keystrokes and overlapping cursor control inputs.

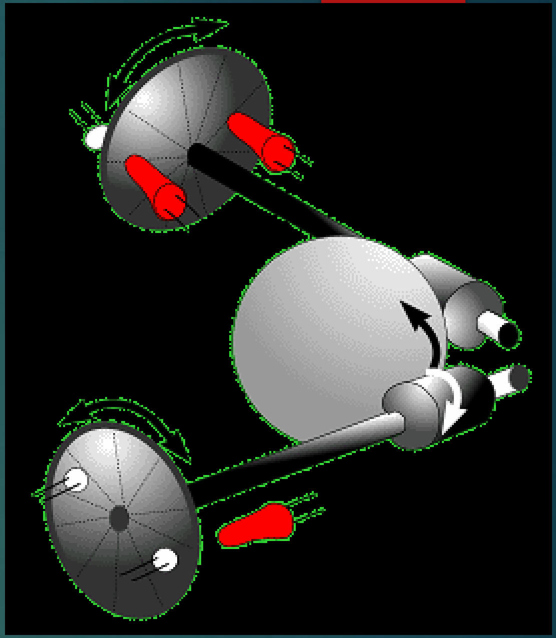
  Step 4: Interpretation and communication (Sensor Module)
  The micro-controller in the sensor module receives the positional information corresponding to the light flashes from the sensor processing core, interprets the events (e.g. keydown, keyup, mouse or touchpad control etc..) and communicates them through an appropriate interface to external devices.

3. Mouse: it is small hand-held box used to position the screen cursor. Wheels or rollers on the bottom of the mouse can be used to record the amount and direction of the movement.

Another method for detecting mouse motion is with an optical sensor. For these systems, the mouse is moved over a special mouse pad that has a grid of horizontal and vertical lines. The optical sensor detects movement across the lines in the grid.

Another type of optical mouse uses technique of digital image processing by means of tiny camera which takes 1500 images per second.

Additional devices can be included in the basic mouse design. The Z mouse includes three buttons, a thumbwheel on the side, a trackball on the top, and a standard mouse ball underneath. With the Z mouse, we can pick up an object, rotate it, and move it in any direction, or we can navigate our viewing position and orientation through a three dimensional scene. It is used in virtual reality, CAD ,and animation.



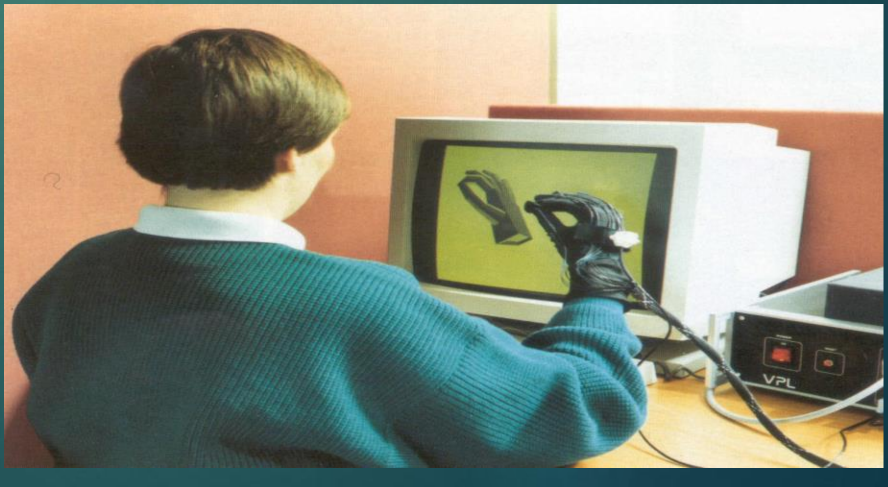
4. **Trackball**: it is a ball that can be rotated with the fingers or palm of the hand to produce screen cursor movement. Potentiometers, attached to the ball, measure the amount and direction of rotation. Trackballs are often mounted on keyboards.

- Space ball : space-ball provides six degrees of freedom. Unlike a trackball, a space-ball does not actually move. 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 for 3D positioning and selection operations in virtual reality systems, animation, CAD etc.

- Joystick: joystick consists of small, vertical lever mounted on a base that used to steer the screen cursor around. Most joysticks select screen positions with actual stick movement; others respond to pressure on the stick.

- Potentiometers mounted at the base of the joystick measure the amount of movement, and springs return the stick to the center position when it is released.
- One or more buttons can be attached as input switches.
- Pressure-sensitive joysticks, also called isometric joysticks, have a non movable stick. Pressure on the stick is measured with strain gauges and converted to movement of the cursor in the direction specified.

7. Data Glove:



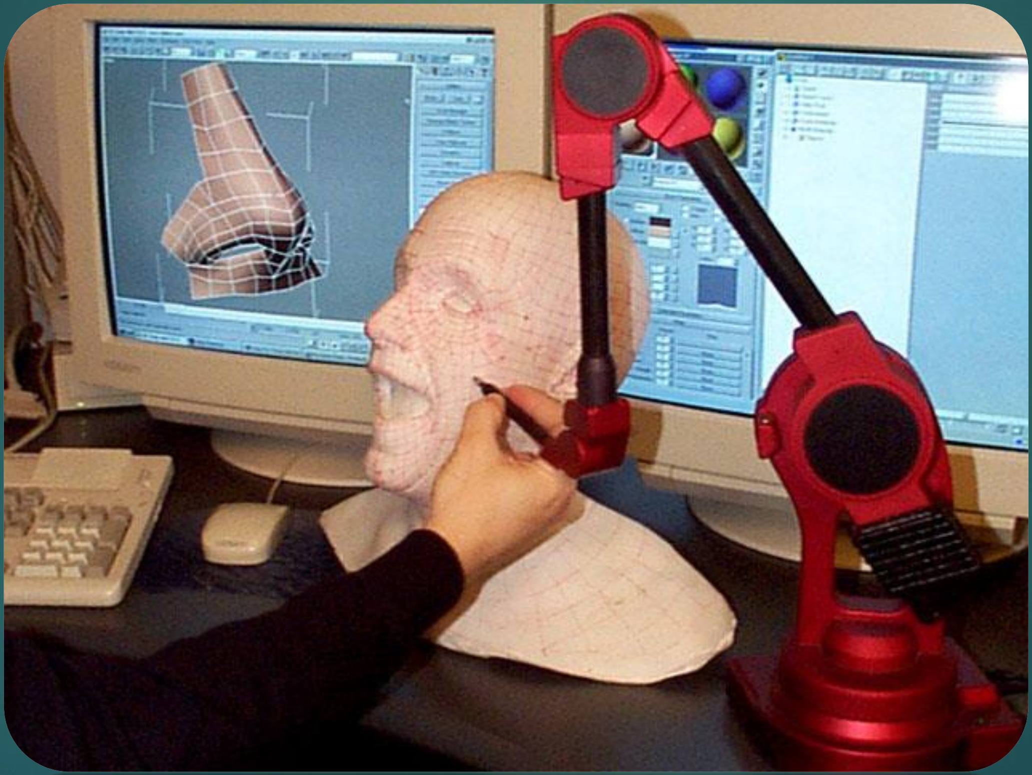
- Data glove can be used to grasp a virtual object.
- The glove is constructed with a series of sensors that detect hand and finger motions. Electromagnetic coupling between transmitting antennas and receiving antennas is used to provide information about the position and orientation of the hand.
- The transmitting and receiving antennas can each be structured as a set of three mutually perpendicular coils, forming a 3D Cartesian coordinate system.
- Input from the glove can be used to position or manipulate objects in a virtual scene

8. **Digitizers**: A common device for drawing, painting, or interactively selecting coordinate positions on an objet is a digitizer. These devices can be used to input coordinate values in either a 2D or 3D space.

- ***Graphics tablet*** (data tablet): it is used to input 2D coordinates by activating a hand cursor or stylus at selected positions on a flat surface. Many graphics tablets are constructed with a rectangular grid of wires embedded in the tablet surface. Electromagnetic pulses are generated in sequence along the wires, and an electric signal is induced in a wire coil in an activated stylus or hand cursor to record a tablet position.
- ***3D digitizers***: 3D digitizers use sonic or electromagnetic transmissions to record positions. One electromagnetic method is similar to data glove. As the points are selected on an object, a wireframe outline of the surface is displayed on the computer screen. Once the surface outline is constructed, it can be shaded with lighting effects to produce a realistic display of the object.

Graphic Tablet

3D Digitizer



9. **Image scanners**: drawings , graphs, photos, or text can be stored for computer processing with an image scanner by passing an optical scanning mechanism over the information to be stored.

- The gradations of gray scale or color are then recorded and stored in an array.
- Once we have the internal representation of a picture, we can apply transformations to rotate, scale, or crop the picture to a particular screen area.
- We can apply various image processing methods to modify the array representation of the picture.

10. **Touch Panels**: touch panels allow displayed objects or screen positions to be selected with the touch. Following are some types of touch panels:

- ***Optical touch panel*** employ a line of infrared light-Emitting Diodes (LED) along one vertical edge and along one horizontal edge of the frame. The opposite vertical and horizontal edges contain light detectors. These detectors are used to record which beams are interrupted when the panel is touched.
- The two crossing beams that are interrupted identify the horizontal and vertical coordinates of the screen position selected.
- Positions can be selected with an accuracy of about ¼ inch. The LED operate at infrared frequencies, so that the light is not visible to a user.
- ***Electrical touch panel*** is constructed with two transparent plates separated by a small distance. One of the plates is coated with a conducting material, and the other plate is coated with a resistive material.
- When the outer plate is touched, it is forced into contact with the inner plate. This contact creates a voltage drop across the resistive plate that is converted to the coordinate values of the selected screen position.

- ***Acoustical touch panels*** use high frequency sound waves generated in the horizontal and vertical directions across a glass plate.
- Touching the screen causes a part of each wave to be reflected from the finger to the emitters.
- The screen position at the point of contact is calculated from a measurement of the time interval between the transmission of each wave and its reflection to the emitter.

11. ***Light Pens***: light pens are pencil shaped devices, used to select screen positions by detecting the light coming from points on the CRT screen.

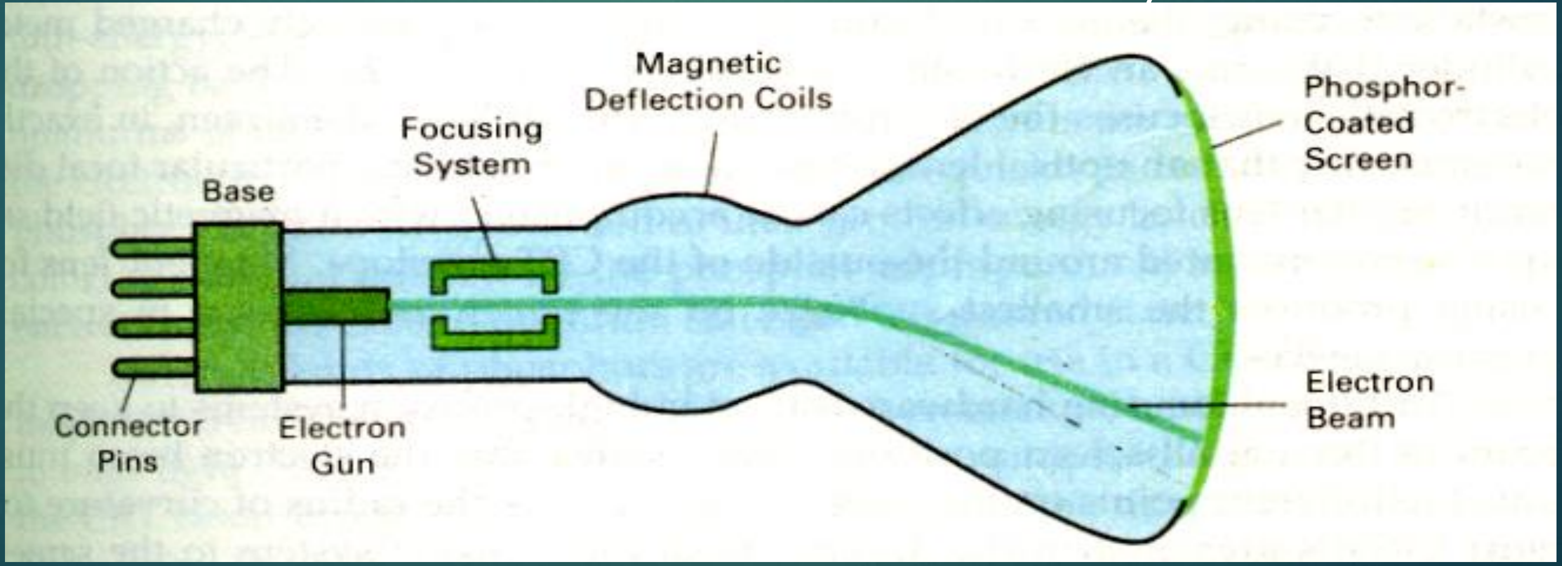
- An activated light pen, pointed at a spot on the screen as the electron beam lights up that spot, generates an electrical pulse that causes the coordinates position of the electron beam to be recorded.
- There are some disadvantages of light pen:

1. When a light pen is pointed at the screen, part of the screen image is obscured by the hand and pen.
2. Long use of light pen can cause arm fatigue.
3. Light pens require special implementations for some applications because they cannot detect positions within black areas.
4. Light pens sometimes give false readings due to background lighting in a room.

12. ***Voice Systems***: Speech recognizers are used in some graphics workstations as input devices to accept voice commands. These systems operate by matching an input against a predefined dictionary of words and phrases.
13. ***Magnetic Ink Character Recognition (MICR):*** A computer can read numbers and letters printed with ink containing magnetic material by means of reader. MICR is used by banks to process cheques. The account details at the bottom of the cheque can be accurately read in this manner since MICR is not affected by dirt.
14. ***Optical Mark Reader (OMR)*** : The Optical Mark Reader (OMR) can read information in the form of numbers or letters and put it into the computer. The marks have to be precisely located as in multiple choice test papers.
15. *Bar Code Reader*: **A bar code is a pattern printed in lines of differing thickness. The system gives fast and error-free entry of information into the computer.**
16. *Magnetic Reader*: **This input device reads a magnetic strip on a card. Handy for security reasons, it provides quick identification of the card's owner.**
17. *Smart Cards Reader*: **This input device stores data in a microprocessor embedded in the card. This allows information, which can be updated, to be stored on the card. This method is used in store cards which accumulate points for the purchaser, and to store phone numbers for cellular phones.**

Video Display Devices

- The primary output device in a graphics system is a video monitor.
- The operation of most video monitors is based on the standard cathode-ray tube



Refresh Cathode-Ray Tubes

- Figure illustrates the basic operation of a CRT.
- A beam of electrons (cathode rays), emitted by an electron gun, passes through focusing and deflection systems that direct the beam toward specified positions on the phosphor-coated screen.
- The phosphor then emits a small spot of light at each position contacted by the electron beam.
- Because the light emitted by the phosphor fades very rapidly, some method is needed for maintaining the screen picture.
- One way to keep the phosphor glowing is to redraw the picture repeatedly by quickly directing the electron beam back over the same points.
- This type of display is called a refresh CRT.

- The primary components of an electron gun in a CRT are the heated metal cathode and a control grid.
- Heat is supplied to the cathode by directing a current through a coil of wire, called filament, inside the cylindrical cathode structure.
- This causes electrons to be "boiled off" the hot cathode surface.

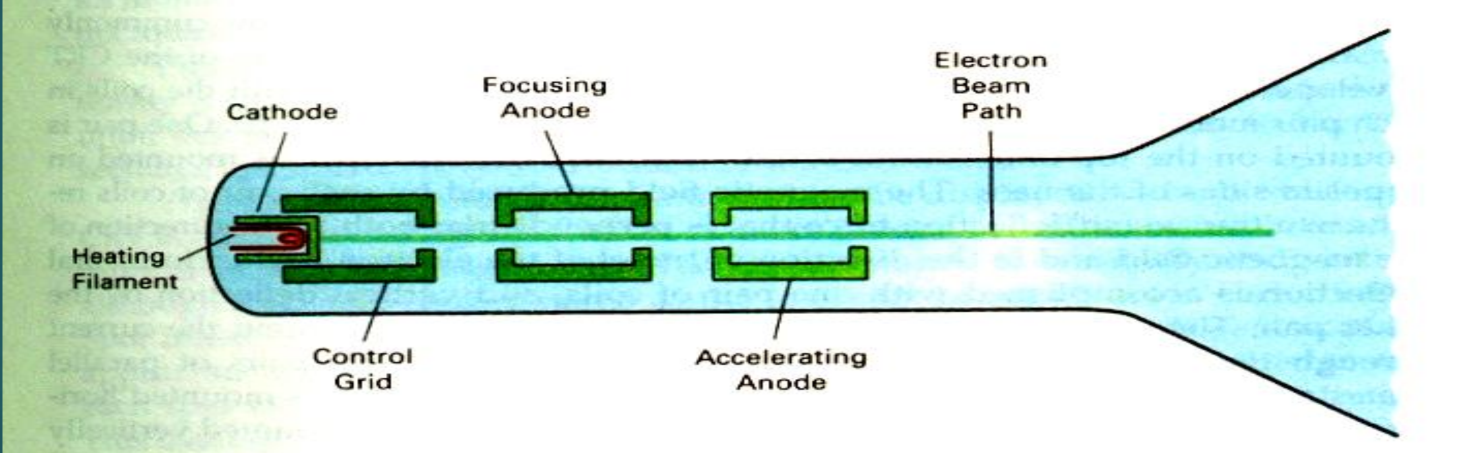


Figure 2-3
Operation of an electron gun with an accelerating anode.

- In the vacum inside the CRT envelope, the free, negatively charged electrons are then accelerated toward the phosphor coating by a high positive voltage.
- The accelerating voltage can be generated with a positively charged metal coating on the inside of the CRT envelope near the phosphor screen, or an accelerating anode can be used.
- Sometimes the electron gun is built to contain the accelerating anode and focusing system within the same unit.
- Intensity of the electron beam is controlled by setting voltage levels on the control grid, which is a metal cylinder that fits over the cathode.
- Since the amount of light emitted by phosphor coating depends on the number of electrons striking the screen ,we control the brightness of a display by varying the voltage on the control grid.

- The focusing system in a CRT is needed to force the electron beam to converge into a small spot as it strikes the phosphor. Otherwise, the electrons would repel each other, and the beam would spread out as it approaches the screen.
- Focusing is accomplished with either electric or magnetic fields.
- Electrostatic focusing is commonly used in television and computer graphics monitors.
- With electrostatic focusing, the electron beam passes through a positively charged metal cylinder that forms an electrostatic lens, as shown in figure.
- Magnetic lens focusing produces the smallest spot size on the screen and is used in special purpose devices.

- The distance that the electron beam travels to different points on the screen varies because the radius of curvature for most CRT is greater than the distance from the focusing system to the screen center.
- Therefore, the electron beam will be focused properly only at the center of the screen. As the beam moves to the outer edges of the screen, displayed images become blurred.
- To compensate for this, the system can adjust the focusing according to the screen position of the beam.
- CRTs are now commonly constructed with magnetic deflection coils mounted on the outside of the CRT envelope.
- Two pairs of coils are used, with the coils in each pair mounted on opposite sides of the neck of the CRT envelope.

- One pair is mounted on the top and bottom of the neck, and the other pair is mounted on opposite sides of the neck.
- Horizontal deflection is accomplished with one pair of coils, and vertical deflection by the other pair.
- The proper deflection amounts are attained by adjusting the current through the coils.
- When electrostatic deflection is used, two pairs of parallel plates are mounted inside the CRT envelope.
- One pair of plates is mounted horizontally to control the vertical deflection, and the other pair is mounted vertically to control horizontal deflection.

- ***Spots of light*** are produced on the screen by the transfer of the CRT beam energy to the phosphor.
- When the electrons in the beam collide with the phosphor coating, they are stopped and their kinetic energy is absorbed by the phosphor.
- Part of the beam energy is converted by friction into heat energy, and the remainder causes electrons in the phosphor atoms to move up to higher quantum-energy levels.
- After a short time, the "excited" phosphor electrons begin dropping back their stable ground state, giving up their extra energy as small quantum of light energy.
- The frequency of the light emitted by the phosphor is proportional to the energy difference between the excited quantum state and the ground state.

- Phosphors are distinguished upon color and persistence.
- ***Persistence*** means how long phosphor continue to emit light after the CRT beam is removed.
- Persistence is defined as the time it takes the emitted light from the screen to decay to one-tenth of its original intensity.
- Lower persistence phosphor are useful for animation; a high-persistence phosphor is useful for displaying highly complex, static pictures.
- ***Resolution***: resolution can be defined as the number of points per centimeter that can be plotted horizontally and vertically, simply the total number of points in each direction.
- In other words, the maximum number of points that can be displayed without overlap on a CRT is referred to as the resolution.

- The resolution of a CRT is dependent on the type of phosphor, the intensity to be displayed, and the focusing and deflection systems.
- High resolution systems are often referred to as ***high-definition systems.***
- The physical size of a graphics monitor is given as the length of the screen diagonal.
- Aspect ratio is a property of video monitors. This number gives the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen.
- An aspect ratio of ¾ means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points.

Raster-Scan Displays

- The most common type of graphics monitor employing a CRT is the raster scan display, based on television technology.
- In raster scan system, 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 the 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. Stored intensity values are then retrieved from the refresh buffer and "painted" on the screen one row(scan line) at a time.
- Each screen point is referred to as a ***pixel*** or ***pel*** (picture element).

- Intensity range for pixel positions depends on the capability of the raster system.
- In a simple black and white system, each screen point is either on or off, so only one bit per pixel is needed to control the intensity of screen positions.
- Bit value of 1 indicates that the electron beam is to be turned on at that position, and a value of 0 indicates that the beam intensity is off.
- On a black and white system with one bit per pixel, the frame buffer is commonly called a ***bitmap***.
- Additional bits are needed when color and intensity variations can be displayed (up to 24 bits per pixel).
- A system with 24 bits per pixel and a screen resolution of 1024 by 1024 requires 3 MB of storage for frame buffer.
- For systems with multiple bits per pixel, the frame buffer is often referred to as a ***pixmap***.

- Refreshing on raster scan displays is carried out at the rate of 60 to 80 frames per second or higher.
- Refresh rates are described in units of cycle per second, or Hertz (Hz), where cycle correspond to one frame (i.e 60 Hz).
- At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line.
- The return to the left of the screen, after refreshing each scan line, is called the ***horizontal retrace*** of the electron beam. And at the end of each frame, the electron beam returns to the top left corner of the screen to begin the next frame is called ***vertical retrace***.

Interlaced Display

- On some raster scan systems, each frame is displayed in two passes using an ***interlaced*** refresh procedure.
- In the first pass, the beam sweeps across every other scan line from top to bottom.
- Then after the vertical retrace, the beam sweeps out the remaining scan lines.
- Interlacing is primarily used with slower refreshing rates.
- This is an effective technique for avoiding flicker, providing that adjacent scan lines contain similar display information.
- However, with animated graphics - especially images that move or change form rapidly - interlacing can produce a fluttering effect which is as irritating as screen flicker.

Random Scan Display

- When operated as a random scan display unit, a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn.
- Random scan monitors draw a picture one line at a time and for this reason are also referred to as ***vector displays*** or ***stroke-writing*** or ***calligraphic displays***.
- The component lines of a picture can be drawn and refreshed by a random-scan system in any specified order.
- Refresh rate on a random scan system depends on the number of lines to be displayed.
- Picture definition is now stored as a set of line drawing commands in an area of memory referred to as the ***refresh display file***. Sometimes it is also called the ***display list***, ***display program***, or simply ***refresh buffer***.

- To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line in turn.
- After all line drawing commands have been processed, the system cycles back to the firs line command in the list.
- Random scan displays are designed to draw all the component lines of a picture 30 to 60 times each second.
- When a small set of lines is to be displayed, each refresh cycle is delayed to avoid refresh rates greater than 60 frames per second. Otherwise, faster refreshing of the set of lines could burn out the phosphor.

Random-Scan Systems v/s Raster-Scan Systems

- Random scan systems are designed for line drawing applications and cannot display realistic shaded scenes as Raster scan systems.
- Since picture definition is stored as a set of line-drawing instructions and not as a set of intensity values for all screen points, vector displays generally have higher resolution than raster systems.
- Vector displays produce smooth line drawings because the CRT beam directly follows the line path. A raster system in contrast, produces jagged lines that are plotted as discrete point sets.

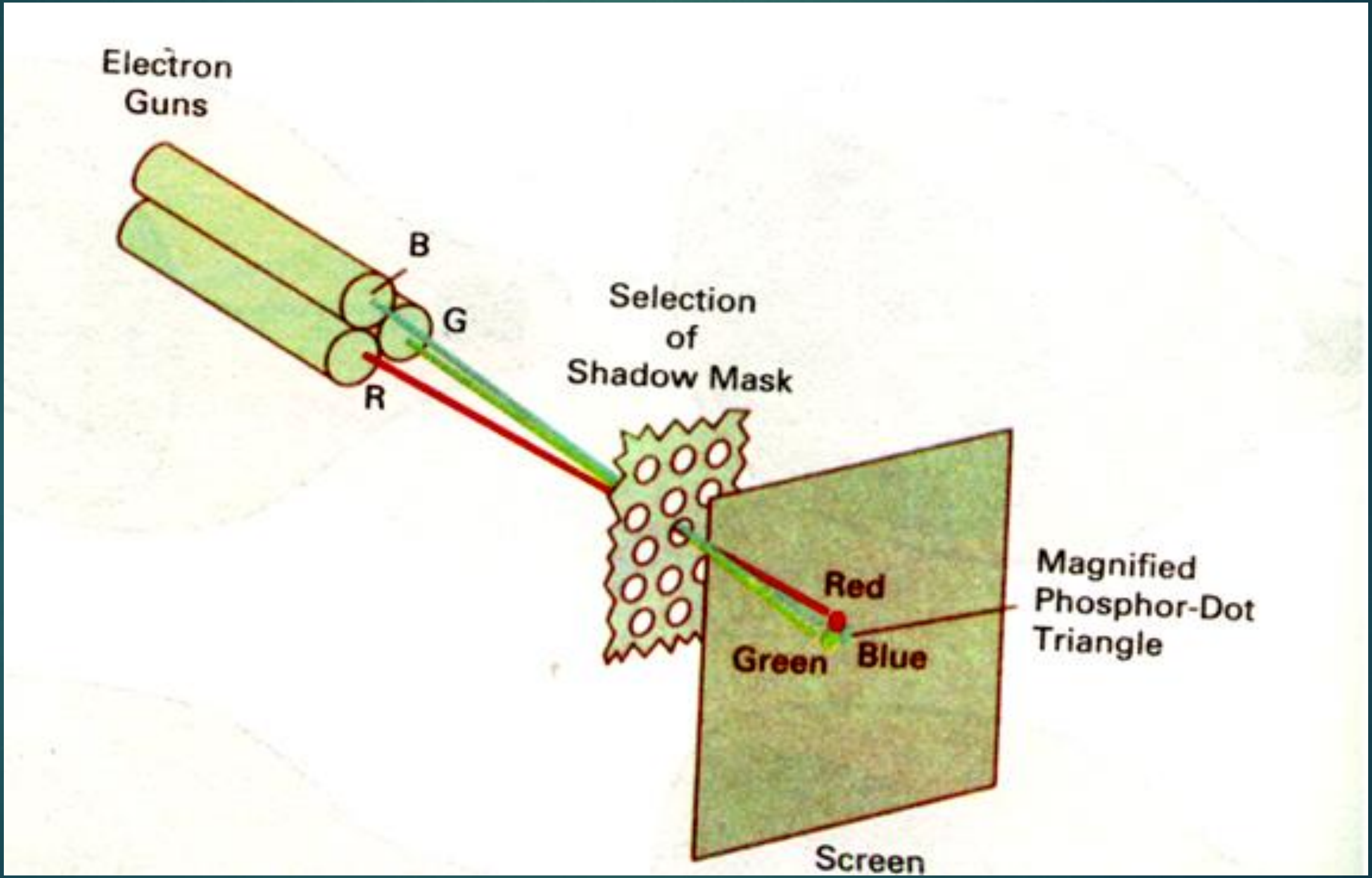
Color CRT Monitors

- A CRT monitor displays color pictures by using a combination of phosphors that emit different-colored light.
- By combining the emitted light from the different phosphors, a range of colors can be generated.
- The two basic techniques for producing colors in CRT are the beam penetration method and the shadow-mask method.

Beam penetration method

- This method for displaying color pictures has been used with random scan monitors.
- Two layers of phosphor, usually red and green, are coated onto the inside of the CRT screen, and the displayed color depends on how far the electron beam penetrates into the phosphor layers.
- A beam of slow electrons excites only the outer red layer.
- A beam of very fast electrons penetrates through the red layer and excites the inner green layer.
- At intermediate beam speeds, combinations of red and green light are emitted to show two additional colors, orange and yellow.
- The speed of the electrons, and hence the screen color at any point, is controlled by the beam-acceleration voltage.
- This method is inexpensive, but produces only four colors. Quality of picture is not good as other methods.

Shadow Mask method



- Shadow-mask methods are commonly used in raster-scan systems because they produce a much wider range of colors than the beam penetration method .
- A shadow mask CRT has three phosphor color dots at each pixel position.
- One phosphor dot emits a red light, another emits a green light, and the third emits a blue light.
- This type of CRT has three electron guns, one for each color dot, and a shadow mask grid just behind the phosphor coated screen.
- Figure shows the ***delta-delta*** shadow-mask method, commonly used in color CRT systems.
- Three electron beams are deflected and focused as a group onto the shadow mask, which contains a series of holes aligned with the phosphor-dot patterns.
- When the three beams pass through a hole in the shadow mask, they activate a dot triangle, which appears as a small color spot on the screen.

- The phosphor dots in the triangles are arranged so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.
- Another configuration for the three electron guns is an ***in-line*** arrangement in which the three electron guns, and the corresponding red-green-blue dots on the screen, are aligned along one scan line instead of in a triangular pattern.
- This in-line arrangement of electron guns is easier to keep in alignment and is commonly used in high-resolution color CRTs.
- We obtain color variations in shadow-mask CRT by varying the intensity levels of the three electron beams.
- By turning off the red and green guns, we get only the color coming from the blue phosphor. Likewise, we can get different colors.

- Color CRTs in graphics systems are designed as RGB monitors.
- These monitors use shadow mask methods and take the intensity level for each electron gun directly from the computer system without any intermediate processing.
- High quality raster graphics systems have 24 bits per pixel in the frame buffer, allowing 256 voltage settings for each electron gun and nearly 17 million color choices for each pixel.
- An RGB color system with 24 bits of storage per pixel is generally referred to as a ***full-color system*** or ***true-color system***.

Direct-View Storage Tubes

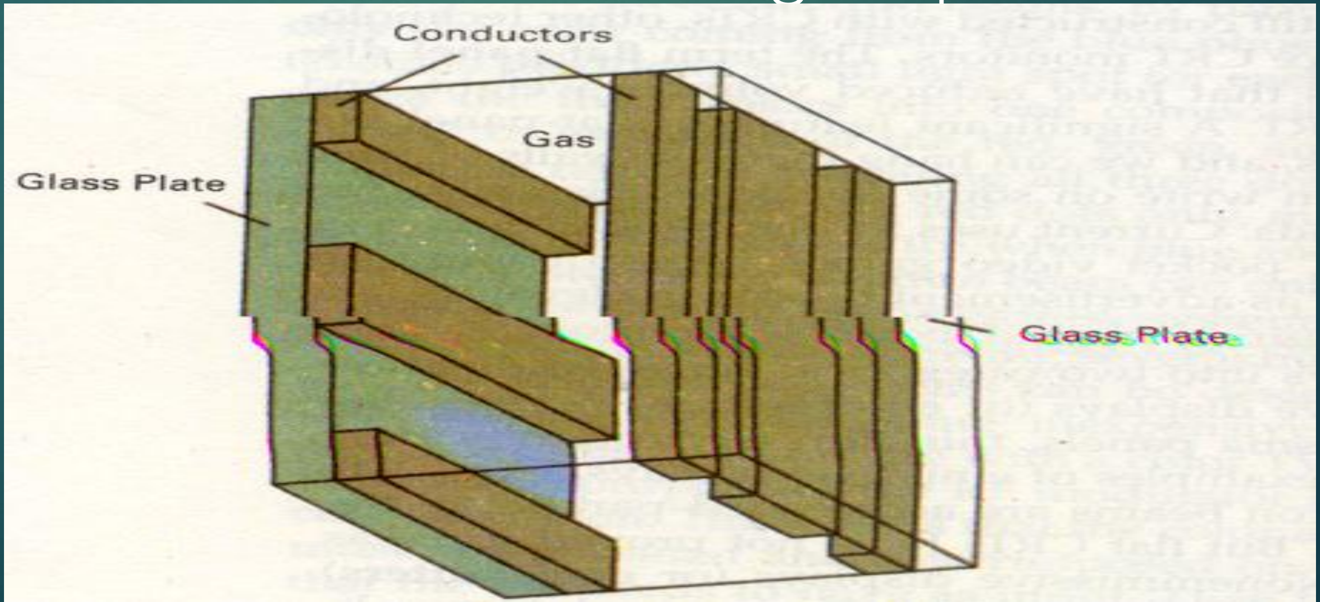
- An alternative method for maintaining a screen image is to store the picture information inside the CRT instead of refreshing the screen.
- A DVST stores the picture information as a charge distribution just behind the phosphor coated screen.
- Two electron guns are used in a DVST. One, the primary gun, is used to store the picture pattern; the second, the flood gun, maintains the picture display.
- Advantage of DVST is that, because no refreshing is needed, very complex pictures can be displayed at very high resolutions without flicker.
- Disadvantage are that they are ordinarily do not display color and that selected parts of a picture cannot be erased. To eliminate a picture section, the entire screen must be erased and the modified picture redrawn.
- This redrawing process can take several seconds for a complex picture. For these reasons, DVST are largely replaced by raster systems.

Flat-Panel Displays

- The term flat-panel-display refers to a class of video devices that have reduced volume, weight, and power requirements compared to a CRT.
- We can separate flat-panel displays in two categories: emissive displays and non-emissive displays.
- The emissive displays are devices that convert electrical energy into light. Plasma panels, thin-film electroluminescent displays, and light-emitting diodes are examples of emissive displays.
- Flat CRTs are also in the market.
- Non-emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. LCD is an example of that.

Plasma panels

- Plasma panels, also called gas discharge displays, are constructed by filling the region between two glass plates with a mixture of gases that usually includes neon.
- A series of vertical conducting ribbons is placed on one glass panel, and a set of horizontal ribbons is built into the other glass panel.



- Firing voltages applied to a pair of horizontal and vertical conductors cause the gas at the intersection of the two conductors to break down into a glowing plasma of electrons and ions.
- Picture definition is stored in a refresh buffer, and the firing voltages are applied to refresh the pixel positions 60 times per second.
- Alternating current methods are used to provide faster application of the firing voltages, and thus brighter displays.
- Separation between pixels is provided by the electric field of the conductors.
- One disadvantage of plasma panels has been that they were strictly monochromatic devices, but systems have been developed that are now capable of displaying color and grayscale.

Light Emitting diode (LED)

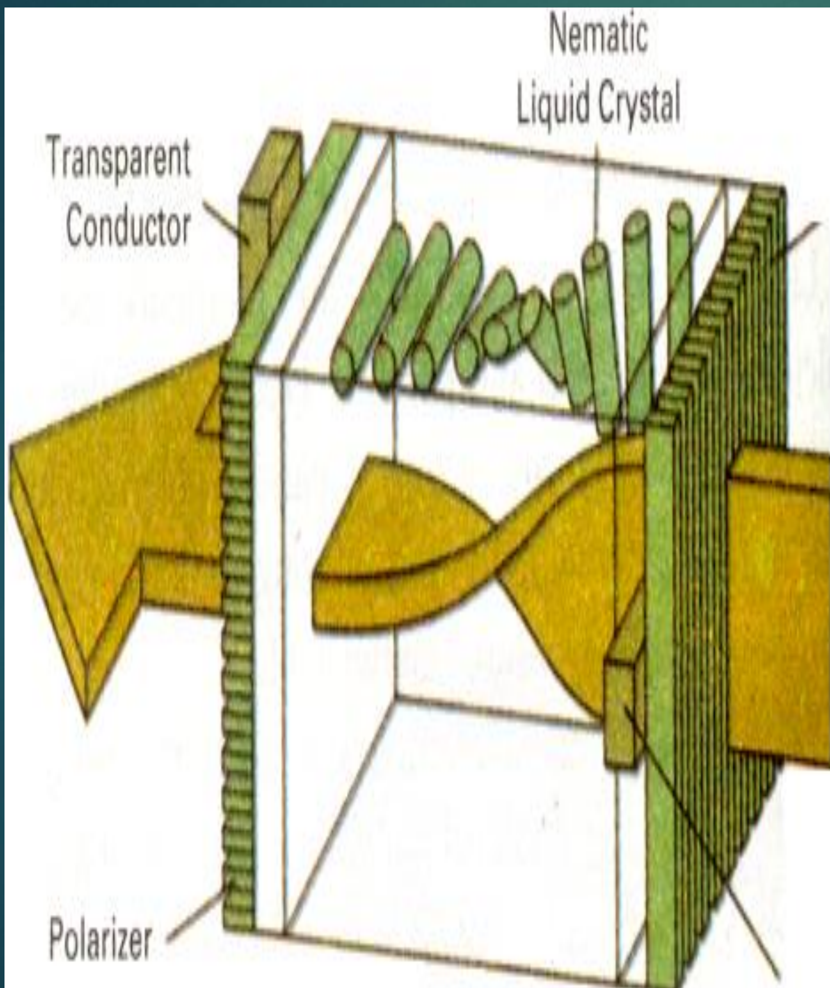
- In LED, a matrix of diodes is arranged to form the pixel positions in the display, and picture definition is stored in a refresh buffer.
- As in scan-line refreshing of a CRT, information is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light patterns in the display.

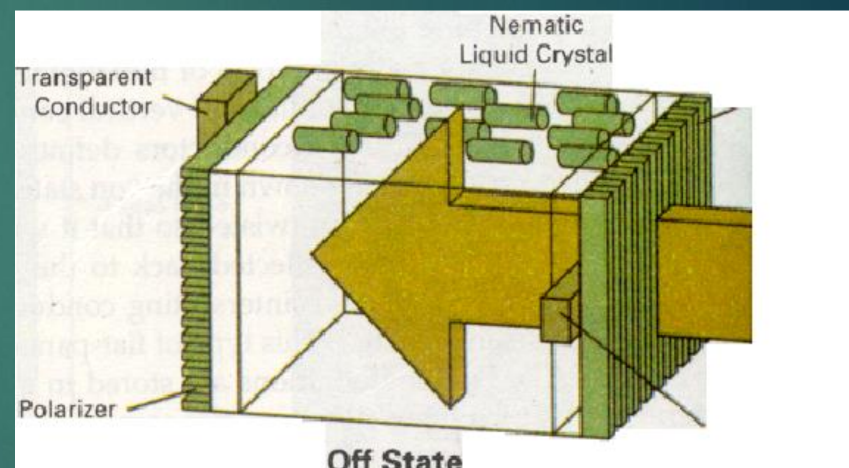
Liquid Crystal Displays

- These non-emissive devices produce a picture by passing polarized light from the surroundings or from an internal light source through a liquid crystal material that can be aligned to either block or transmit the light.
- The term liquid crystal refers to the fact that these compounds have a crystalline arrangement of molecules, yet they flow like a liquid.
- Flat panel displays commonly use nematic (threadlike) liquid crystal compounds that tend to keep the long axes of the rod-shaped molecules aligned.
- A flat panel display can then be constructed with a nematic liquid crystal, as demonstrated in figure.

On State

Off State





- Two glass plates, each containing a light polarizer at right angles to the other plate, sandwich the liquid-crystal material.
- Rows of horizontal transparent conductors are built into one glass plate, and columns of vertical conductors are put into the other plate.
- The intersection of two conductors defines a pixel position.
- Normally the molecules are aligned as shown in the "on state" . Polarized light passing through the material is twisted so that it will pass through the opposite polarizer.
- The light is then reflected back to the viewer.
- To turn off the pixel, we apply a voltage to the two intersecting conductors to align the molecules so that the light is not twisted.
- This type of flat panel device is referred to as a ***passive-matrix LCD.***
- Back lighting is also commonly applied using solid-state electronic devices, so that the system is not completely dependent on outside light sources.

- Picture definitions are stored in a refresh buffer, and the screen is refreshed at the rate of 60 Hz.
- Colors can be displayed by using different materials of dyes and by placing a triad of color pixels at each screen location.
- Another method for constructing LCD is to place transistor at each pixel location, using thin-film transistor technology.
- The transistors are used to control the voltage at pixel locations and to prevent charge from gradually leaking out of the liquid-crystal cells.
- These devices are called ***active-matrix displays***.

Three-Dimensional Viewing Devices

- Graphics monitors for the display of three-dimensional scenes have been devised using a technique that reflects a CRT image from a vibrating, flexible mirror.
- As the varifocal mirror vibrates, it changes focal length.
- These vibrations are synchronized with the display of an object on a CRT so that each point on the object is reflected from the mirror into a spatial position corresponding to the distance of that point from a specified viewing position.
- This allows us to walk around an object or scene and view it from different sides.

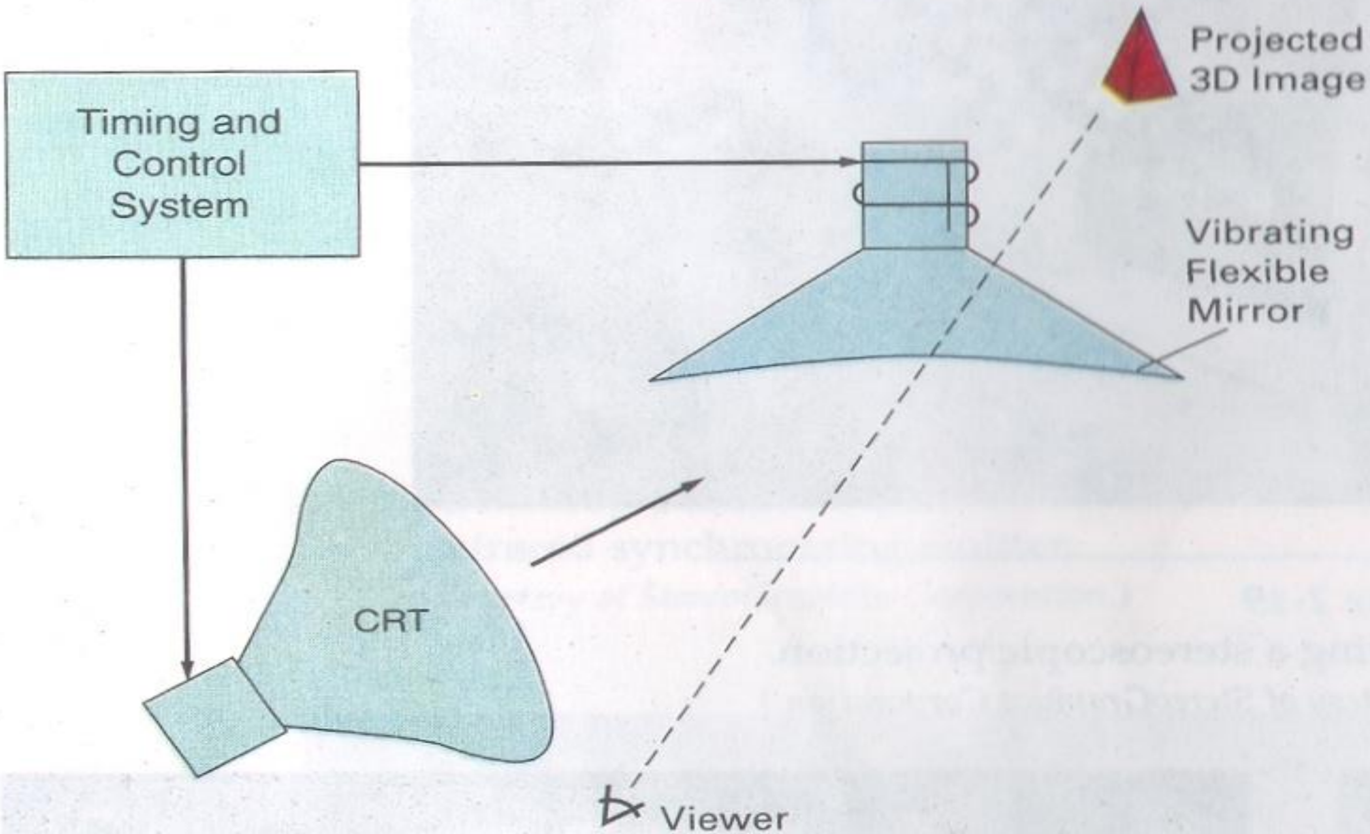


Figure 2-17
Operation of a three-dimensional display system using a vibrating mirror that changes focal length to match the depth of points in a scene.

Simple Raster Display System

- The simplest and most common raster display system organization is shown in figure 4.18.
- A portion of the memory also serves as the pix map.
- The video controller displays the image defined in the frame buffer, accessing the memory through a separate access port as often as the raster-scan rate.
- In many systems, a fixed portion of memory is permanently allocated to the frame buffer.
- Some systems have several interchangeable memory areas.
- In the case where system can designate any part of memory for the frame buffer, the system may be organized as shown in figure 4.19.
- The simple raster display system organizations are used in many inexpensive personal computers, but has a number of disadvantages.

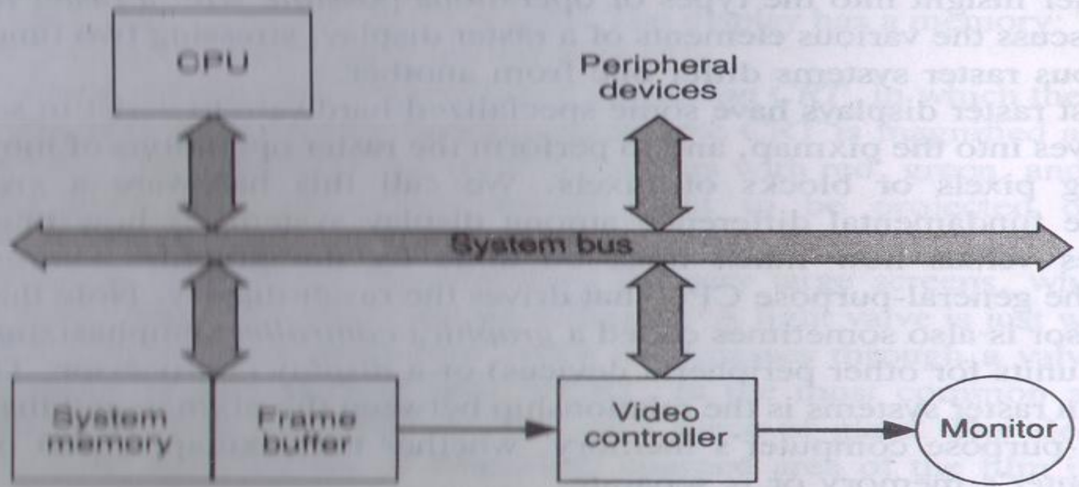


Fig. 4.18 A common raster display system architecture. A dedicated portion of the system memory is dual-ported, so that it can be accessed directly by the video controller, without the system bus being tied up.

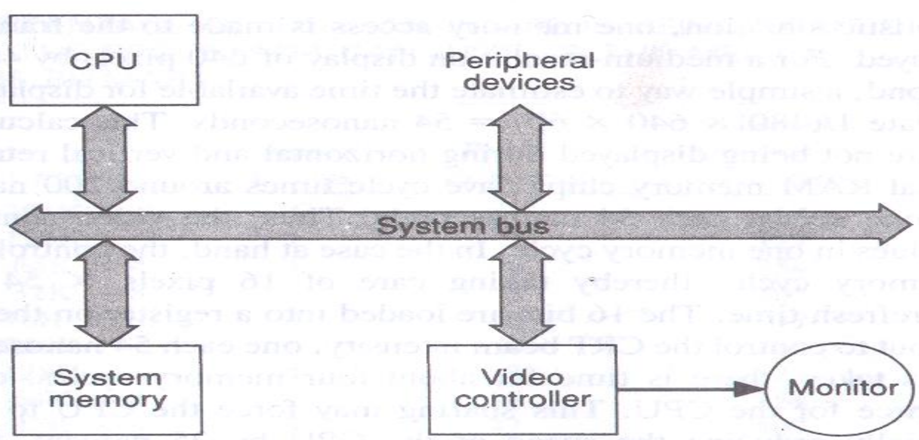


Fig. 4.19 A simple raster display system architecture. Because the frame buffer may be stored anywhere in system memory, the video controller accesses the memory via the system bus.

- In other words, a simple raster-display system contains a CPU, system bus, main memory, frame buffer, video controller, and CRT display.
- In such a system, the CPU performs all the modeling, transformation, and display computations, and writes the final image to the frame buffer.
- The video controller reads pixel data from the frame buffer in raster-scan order, converts digital pixel values to analog, and drives the display.

Problems in SRDS

- SRDS is inexpensive to build, but has a number of disadvantages.
- First, scan conversion in software is slow. For example, the (x,y) address of each pixel on a line must be calculated, then must be translated into a memory address consisting of a byte and bit-within-byte pair.
- Each of the individual steps is simple, each is repeated many times.
- The second disadvantage of this architecture is that as the addressability or the refresh rate of the display increases, the number of memory cycles available to the CPU.
- The CPU slows down, especially with the architecture in fig 4.19. With the dual-porting of part of the system memory shown figure 4.18, the slowdown occurs only when the CPU is accessing the frame buffer, usually for scan conversion or raster operations.

Solutions

- A partial solution, suitable for low-resolution displays, is to place the frame buffer on an isolated bus. This allows video scanout to occur simultaneously with CPU operations that do not affect the frame buffer.
- Second partial solution is to take advantage of DRAM's (Dynamic random access memory)page-mode feature. Since video scanout accesses memory locations in order, DRAM page misses are infrequent, so the frame buffer can run at almost twice its normal speed. We can also used dedicated Cache.
- Third approach is to duplicate the frame-buffer memory, creating a double-buffered system in which the image in one buffer is displayed while the image in the other buffer is computed.
- Video RAM can also be used.

Display Processor Systems

- To build a system with higher performance than the single- CPU system described in the previous section, we must either remove some of the graphics burden from the CPU or increase the CPU's ability to perform these tasks.
- The strategies to increase performance by additional processor generally fall into three categories:

1. Coprocessors that share the system bus with the main CPU
2. Display processors with their own buses and memory systems
3. Integrated processors containing internal hardware support for graphics operations.

Multiprocessing

- To perform multiple operations concurrently and to perform multiple reads and writes to memory concurrently, we need concurrent processing.
- Concurrent processing, or multiprocessing, is the basis of virtually all high-performance graphics architectures.
- Multiprocessing has two basic forms: pipelining and parallelism.
- A pipeline processor contains a number of processing elements (PEs) arranged such that the output of one becomes the input of the next.
- The PEs of a parallel processor are arranged side by side and operate simultaneously on different portions of the data.

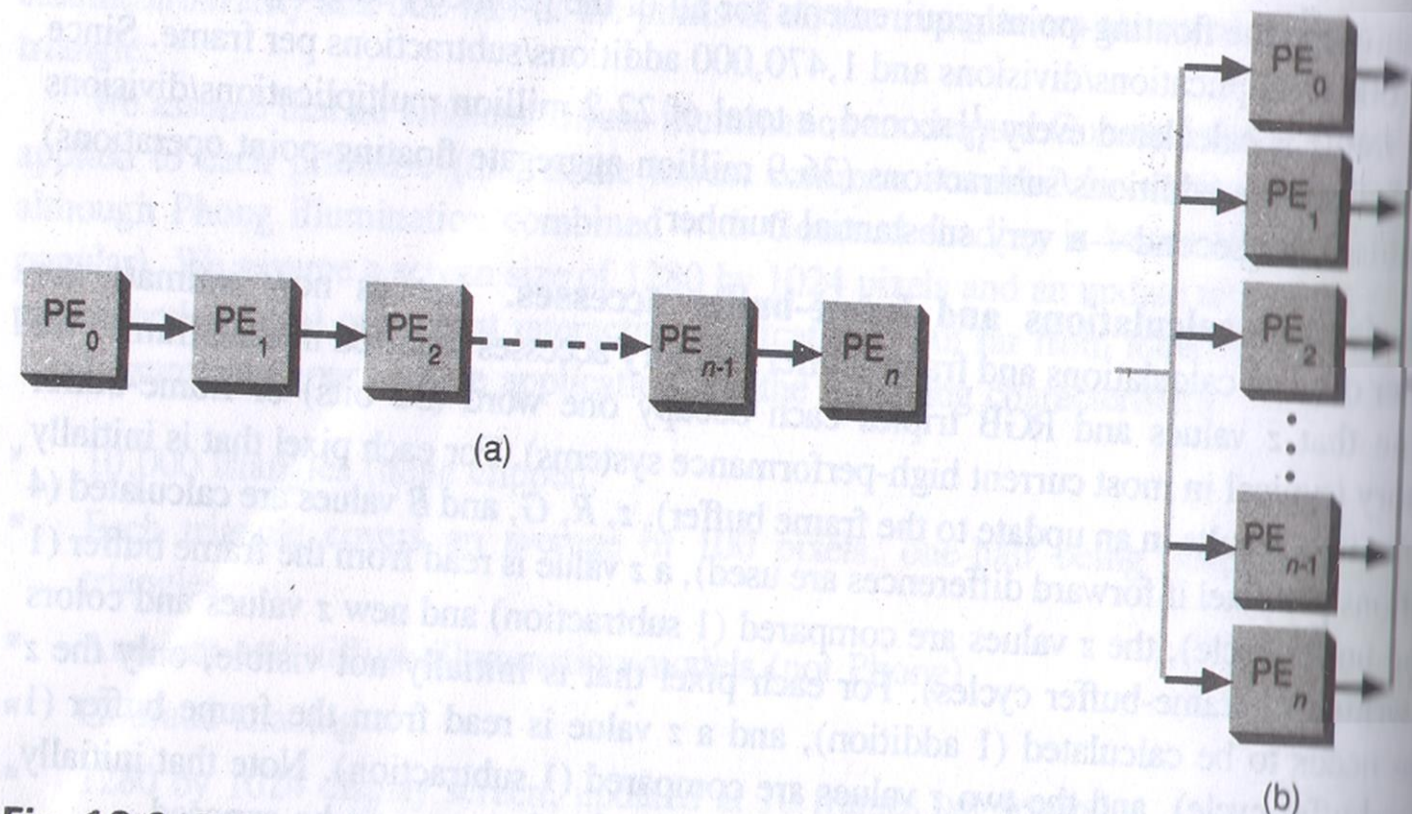


Fig. 18.9 Basic forms of multiprocessing: (a) pipelining, and (b) parallelism.

Pipelining

- To pipeline a computation, we partition it into stages that can be executed sequentially in separate PEs.
- A pipeline can run only as fast as its slowest stage, so the processing load should be distributed evenly over the PEs. If this is not possible, PEs can be sized according to the jobs they must perform.
- An important issue in pipeline systems is ***throughput v/s latency***.
- Throughput is the overall rate at which data are processed; latency is the time required for a single data element to pass from the beginning to the end of the pipeline.
- Some calculations can be pipelined using a large number of stages to achieve very high throughput but pipeline latency increases with pipeline length.

Parallelism

- To parallelize a computation, we partition the data into portions that can be processed independently by different PE.
- Homogeneous parallel processors contain PE of same type; heterogeneous parallel processors contain PE of different types.
- Parallel processors can be distinguished between two types: SIMD and MIMD.
- Processors that operate in lock step generally share a single code store and are called single instruction multiple data(SIMD).
- Processors that operate independently must have a separate code store for each PE and are called multiple instruction multiple data (MIMD) processors.

SIMD processors

- Because all the PE in a SIMD processor share a single code store, SIMD processors are generally less expensive than MIMD processors.
- They do not perform well on algorithms that contain conditional branches or that access data using pointers or indirection.
- PE generally contain an enable register to qualify write operations. Only PE whose enable register are set, write the results of computations.
- Algorithms with few conditional branches execute efficiently on SIMD processors.

MIMD processors

- MIMD processors are more expensive, since each PE must have its own code store and controller.
- They are not constrained to operate in lock state.
- MIMD processors suffer no disadvantage when they encounter conditional branches; each PE makes an independent control flow decision, skipping instructions that do not need to be executed.
- Since processors may start and end at different times and may process data at different rates, synchronization and load balancing are more difficult.