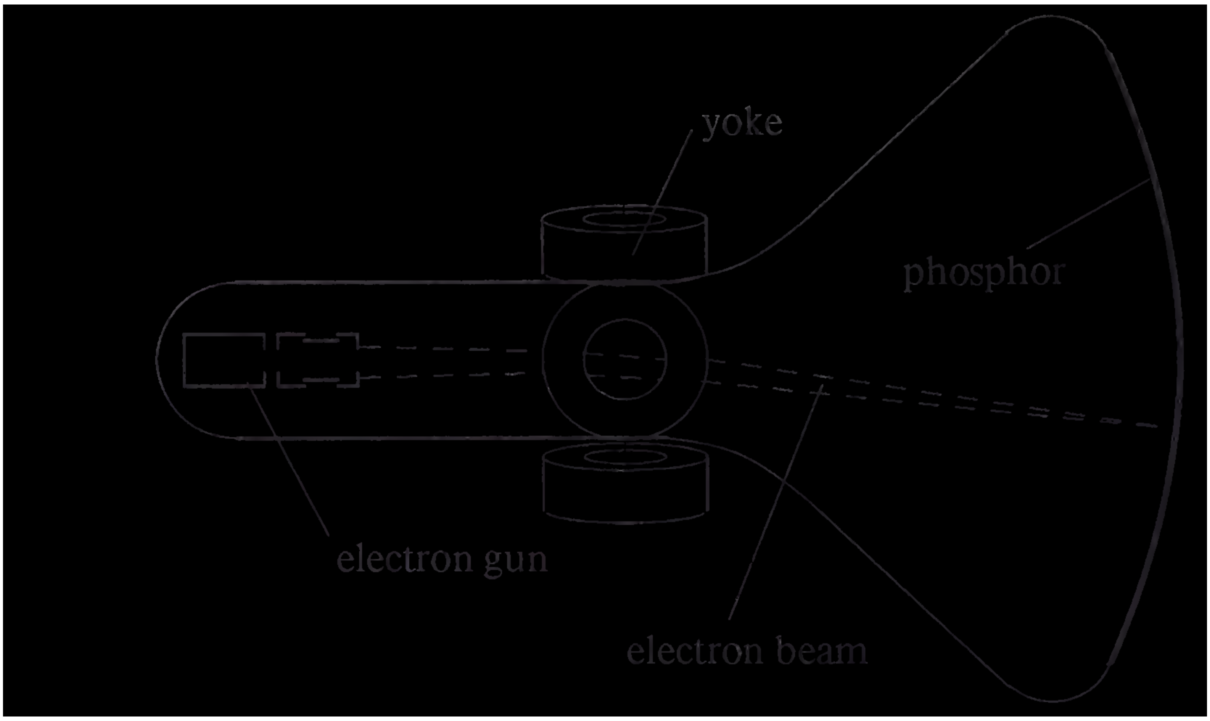
Computer Graphics

Lecture 3

Video Display Devices:

Typically, the primary output device in a graphics system is a video monitor (Fig.2-1). The operation of most video monitors is based on the standard cathode-ray tube (CRT) design, but several other technologies exist and solid-state monitors may eventually predominate.

Diagram below 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 the filament, inside the cylindrical cathode structure. This causes electrons to be 'boiled off" the hot cathode surface. In the vacuum 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 in overview of Graphics Systems side 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.

Raster-Scan Displays

The most common type of graphics monitor employing a CRT is the raster-scan display, based on television technology. In a 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 to create a pattern of illuminated spots. Picture definition is stored in a 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 (Fig. 2-2). Each screen point is referred to as a pixel or pel (shortened form of picture element). The capability of a raster-scan system to store intensity information for each screen point makes it well suited for the realistic display of scenes containing subtle shading and colour patterns. Home television sets and printers are examples of other systems using raster-scan methods.

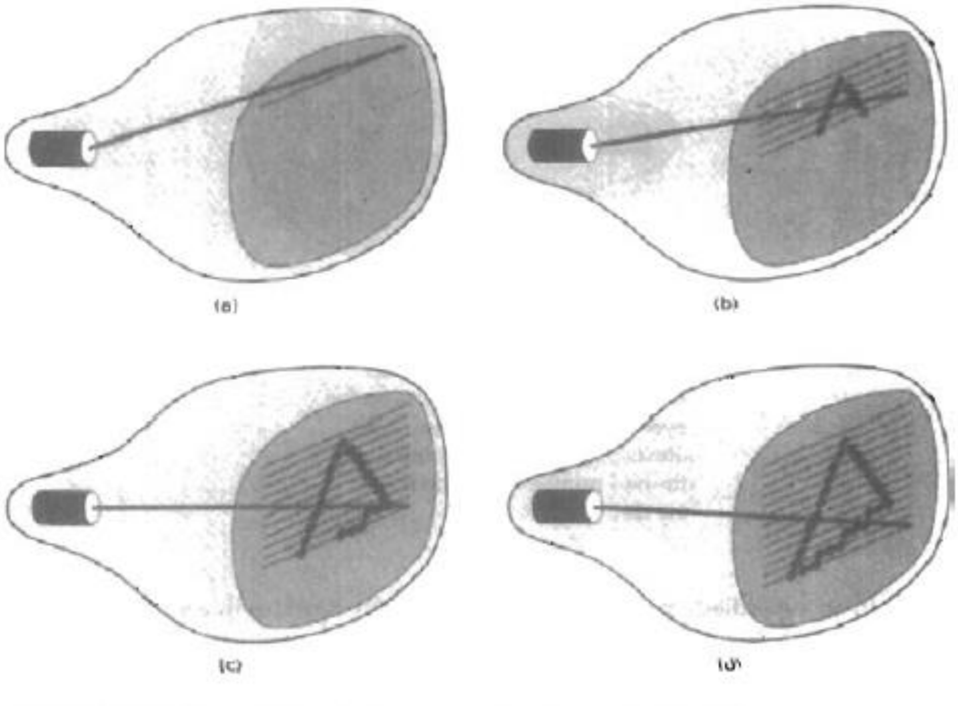


Figure 2-2

A raster-scan system displays an object as a set of discrete points across each scan line.

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. For a bilevel system, a 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 to be off. Additional bits are needed when colour and intensity variations can be displayed. Up to 24 bits per pixel are included in high-quality systems, which can require several megabytes of storage for the frame buffer, depending on the resolution of the system. A system with 24 bits per pixel and a screen resolution of 1024 bv 1024 requires 3 megabytes of storage for the frame buffer. On a black-and-white system with one bit per pixel, the frame buffer is commonly called a bitmap. 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, although some systems are designed for higher refresh rates.

Sometimes, refresh rates are described in units of cycles per second, or Hertz(Hz), where a cycle corresponds to one frame. Using these units, we would describe a refresh rate of 60 frames per second as simply 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 (displayed in 1/80th to 1/60th of a second), the electron beam returns (vertical retrace) to the top left comer of the screen to begin the next frame

Random-Scan Displays

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 (Fig. 2-3). A pen plotter operates in a similar way and is an example of a random-scan, hard-copy device.

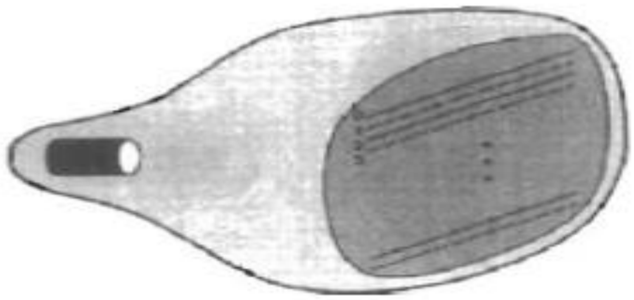


Figure 2-2

Interlacing scan lines on a raster-scan display. First, all points on the even-numbered (solid) scan lines are displayed and then all points along the odd-numbered (dashed) lines are displayed.

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 r e f e d to as the refresh display file. Sometimes the refresh display file is called the display list, display program, or simply the 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 first 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. High quality vector systems are capable of handling approximately 100,000 "short" lines at this refresh rate. 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 are designed for line drawing applications and cannot display realistic shaded scenes. 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. Also, 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.