Computer Graphics

Lecture 2

Working Of Graphics Display:

The modern graphics display is extremely simple in construction. It consists of three components: a digital memory, or frame buffer, in which the displayed image is stored as a matrix of intensity values; a television monitor, i.e., a home TV set without the tuning and receiving electronics; and a simple interface, called the display controller that passes the contents of the frame buffer to the monitor. The image must be passed repeatedly to the monitor, 30 or more times a second, in order to maintain a steady picture on the screen.

Inside the frame buffer the image is stored as a pattern of binary digital numbers, which represent a rectangular array of picture elements, or pixels. In the simplest case, where we wish to store only black-and-white images, we can represent black pixels by Is in the frame buffer, and white pixels by Os. Thus a 16 X 16 array of black and white pixels could be represented by the binary values stored in the 32 8-bit bytes shown in Figure 1-5 (a byte is an 8-bit binary unit of digital data).

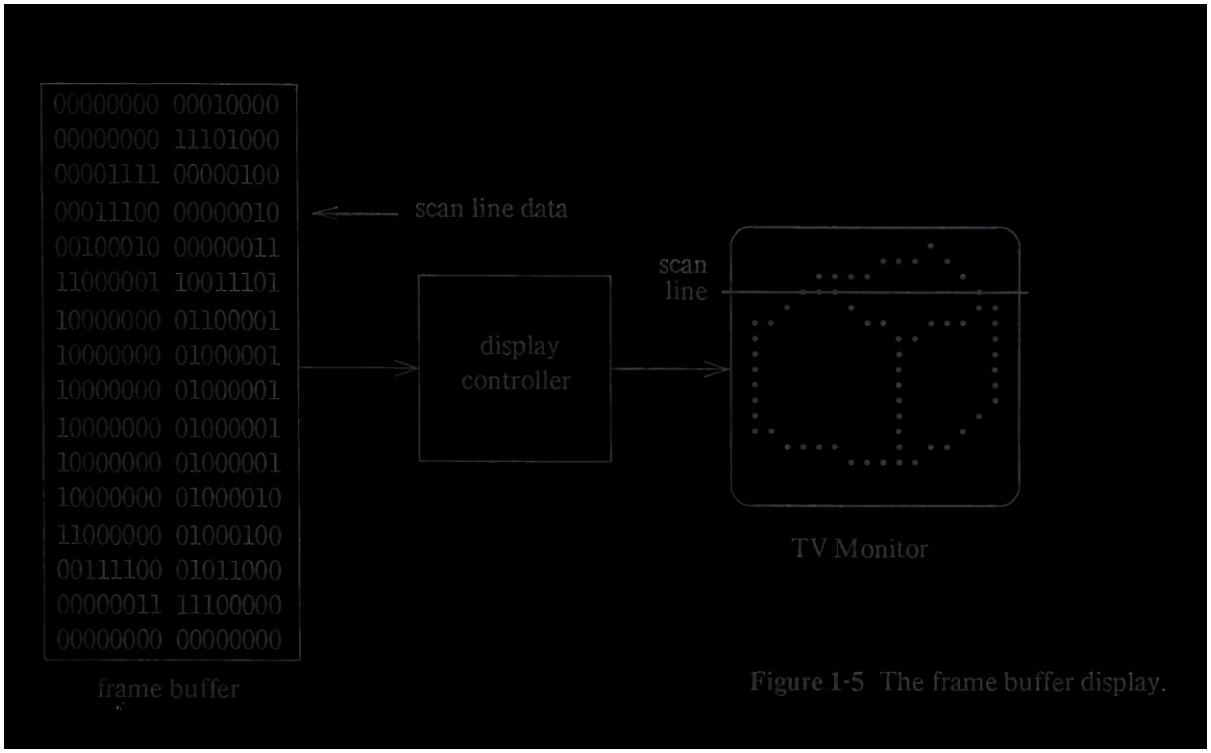


Figure 1-5 The frame buffer display.

The display controller simply reads each successive byte of data from the frame buffer and converts its Os and Is into the corresponding video signal. This signal is then fed to the TV monitor, producing a black-and-white pattern on the screen, like the wheel shown in Figure 1-6. The display controller repeats this operation 30 times a second and thus maintains a steady picture on the TV screen.

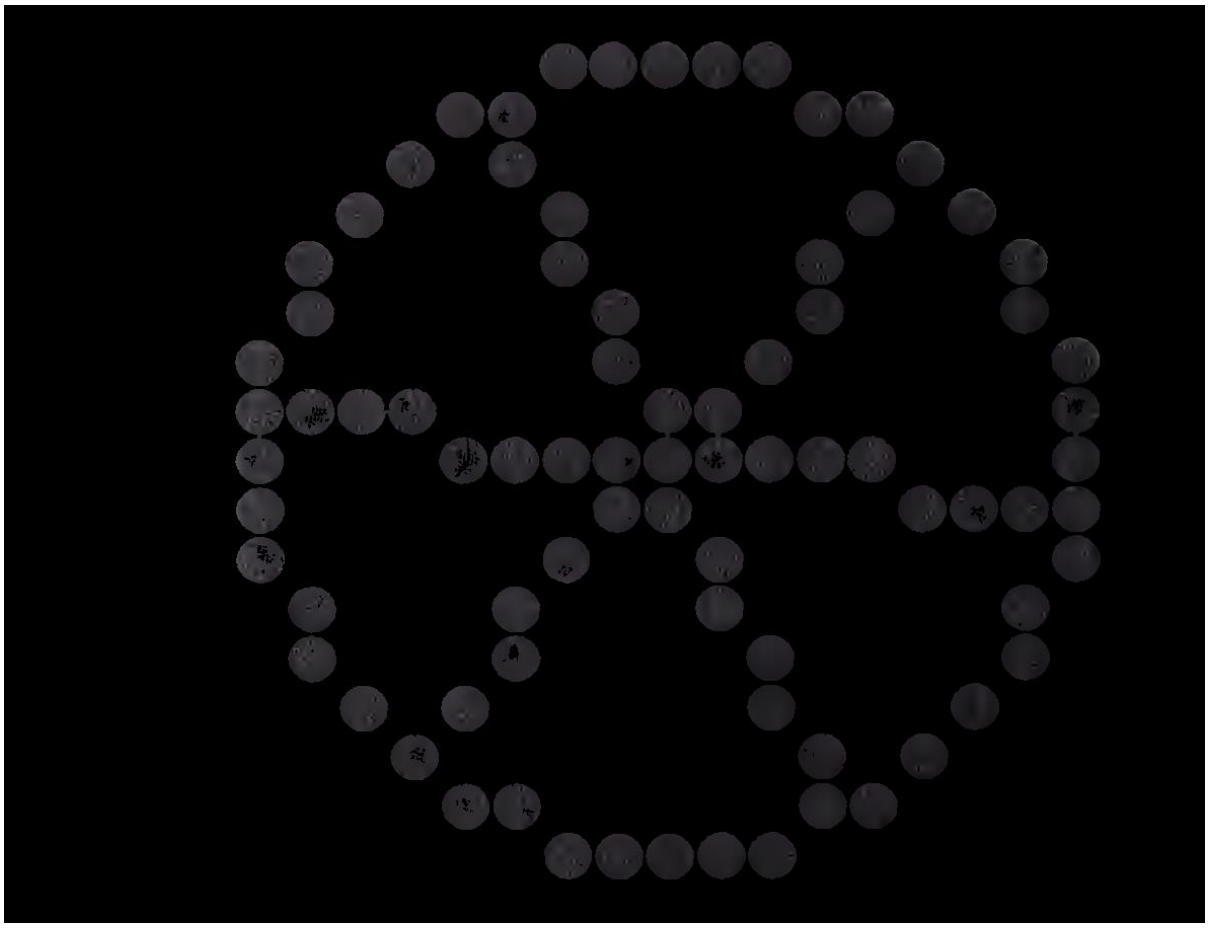


Figure 1-6.

The frame-buffer display described above is an example of a point-plotting display device. The smallest picture unit accepted by such displays is a single dot, variously termed a point or a **pixel**. To construct a useful picture on a point-plotting display we must build the picture out of many hundreds of pixels, each generated by a separate command from the computer. Lines and curves must be drawn with closely spaced pixels; to display a text character, i.e., a letter or a digit, we use a pattern, or matrix, of pixels.

Figure 1.7 is an enlarged picture of lines and text characters constructed on a point-plotting display.

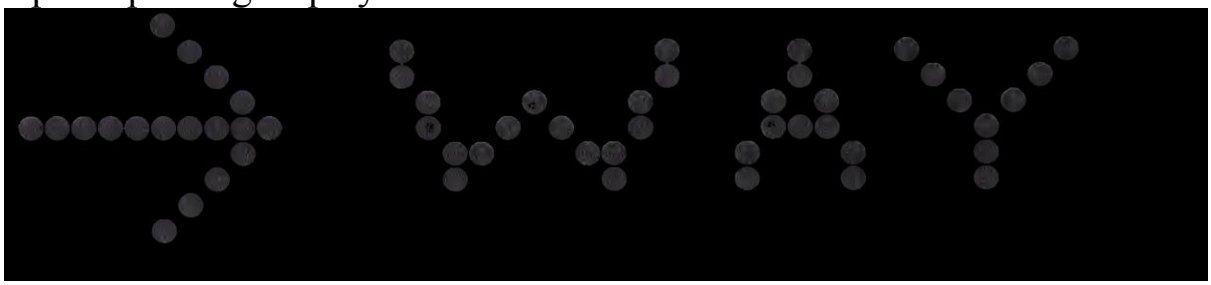


Figure 1.7

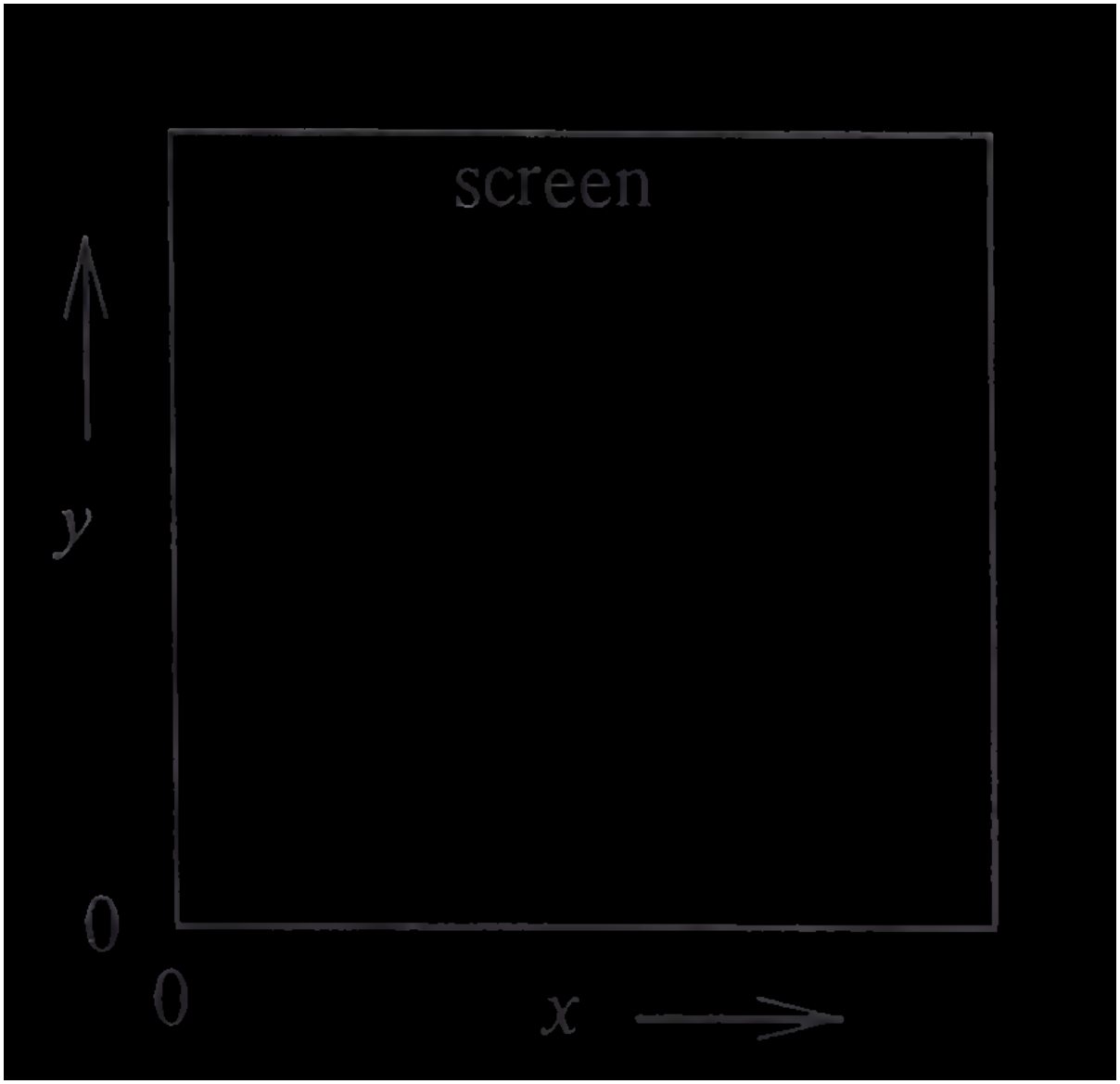
Lines and text on a point-plotting display, enlarged to show individual pixels

The very first graphical displays were of the point-plotting variety. They did not use frame buffers but were fed with a stream of point coordinates by the computer. Only a very limited number of points could be displayed in this fashion without flicker.

Point-plotting displays of this kind were made obsolete by the introduction of line-drawing displays in the mid-1960s. The line-drawing display can draw complete segments of straight lines without plotting each individual pixel on the line; it therefore has a much higher capacity than the point-plotting display for line drawings. It also does away with the need to compute the position of each pixel in the picture.

COORDINATE SYSTEMS:

Point-plotting techniques are based on the use of a Cartesian coordinate system. Points are addressed by their x and y coordinates; the value of x increases from left to right and y likewise from bottom to top as shown in the diagram below.



Points are plotted in response to digital signals from the computer. This means that they cannot be positioned with infinite precision; instead we are limited by the precision of the digital values presented to the display. For example, if x and y are passed to the display each as a 10-bit binary number, there can be only 1024 (= 2^{10}) distinct x-coordinate values and only 1024 for y. The screen offers us a 1024 X 1024 array of positions, at any one of which a dot may be displayed.

What determines the precision of a display? In most cases precision is based on the resolution of the display screen. This is the number of visibly distinct dots that can be displayed in a given area of the screen. A typical display

might have a resolution of 100 dots per inch, indicating that two dots 1/100 inch apart can just be distinguished from each other. Nothing is gained by increasing coordinate precision much beyond the resolution of the screen because the observer will not be able to tell the difference. If precision is much less than resolution, however, there will be resolvable points on the screen at which it is impossible to display a dot; this will cause visible gaps in lines. Hence when a display is designed, its coordinate precision is made approximately equal to screen resolution.

Given the coordinate precision and the size of the screen, we can arrive at the number of addressable points. A display with 100 dots per inch resolution cannot easily be built with a screen much larger than 12 inches square. Therefore most displays allow no more than 1200 points to be addressed in each direction. The value 1024 is popular, as it makes full use of ten-bit integer coordinates, but displays have been built with as many as 4096 X 4096 addressable points and with as few as 256 X 256.

To summarize, most interactive computer displays marketed today use a Cartesian coordinate system, with 10 bits of x and y coordinate precision; display screens generally measure about 10 inches (30 centimeters) square. The practice of using integer coordinate values and of placing the origin at the lower left-hand corner of the screen, as shown in Figure 2.1, is fairly common; in the context of viewing transformations.

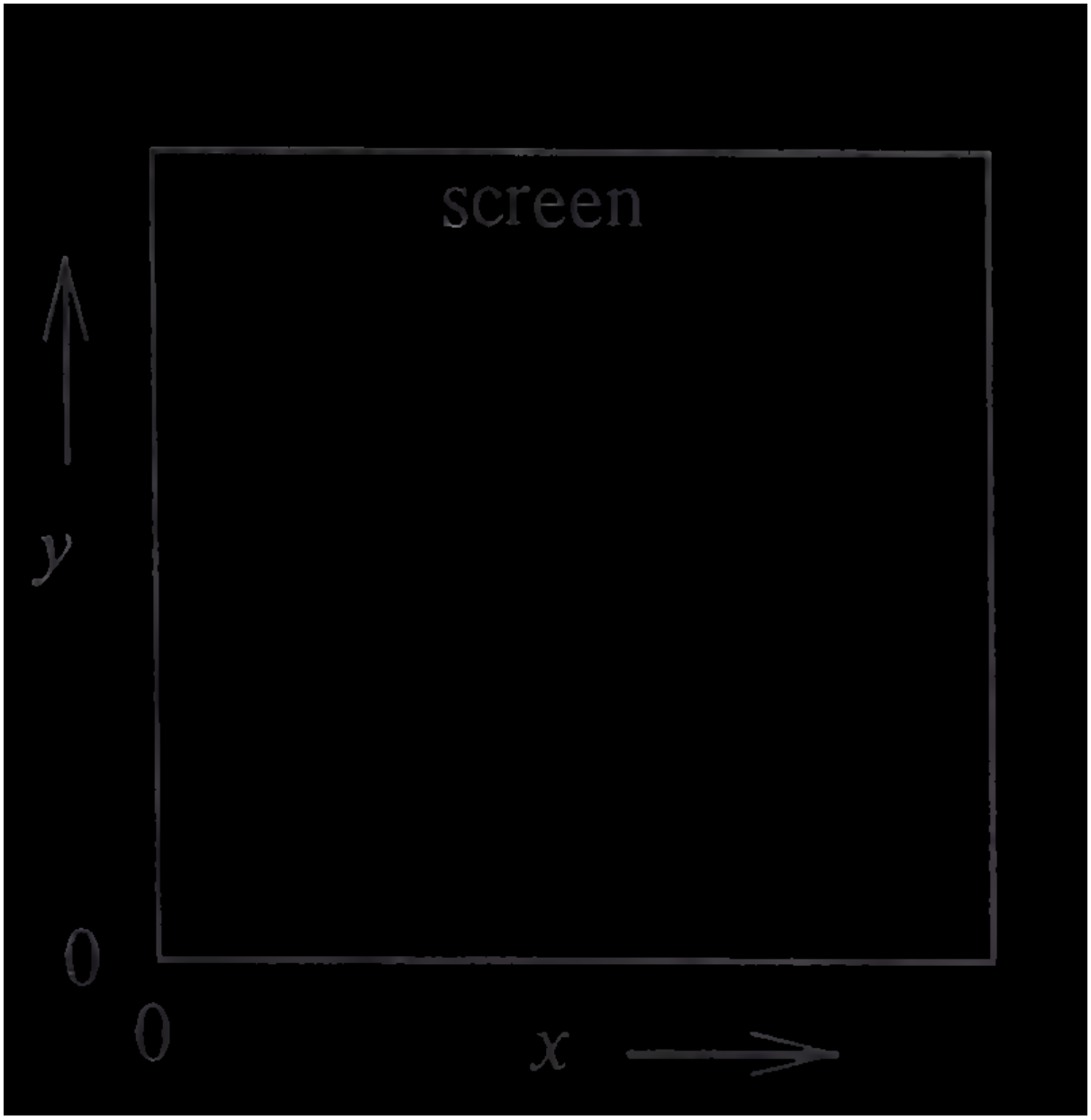


Figure 2.1
The Cartesian screen coordinate system.