Fundamentals of Computer Graphics

The term computer graphics describes any use of computers to create and manipulate images. This book introduces the algorithmic and mathematical tools that can be used to create all kinds of images—realistic visual effects, informative technical illustrations, or beautiful computer animations. Graphics can be two- or three-dimensional; images can be completely synthetic or can be produced by manipulating photographs. This book is about the fundamental algorithms and mathematics, especially those used to produce synthetic images of three-dimensional objects and scenes.

Actually doing computer graphics inevitably requires knowing about specific hardware, file formats, and usually a graphics API (see Section 1.3) or two. Computer graphics is a rapidly evolving field, so the specifics of that knowledge are a moving target. Therefore, in this book we do our best to avoid depending on any specific hardware or API. Readers are encouraged to supplement the text with relevant documentation for their software and hardware environment. Fortunately, the culture of computer graphics has enough standard terminology and concepts that the discussion in this book should map nicely to most environments.

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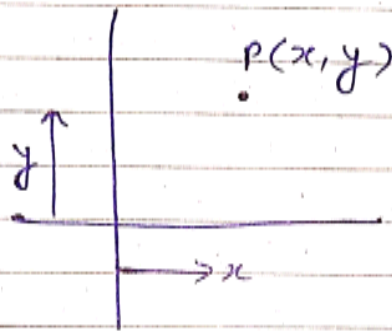
Q. Define point ?

Ans The most basic graphical element in computer graphics, which can be completely defined by an ordered pair of user co-ordinates is called as point.



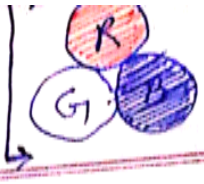
where x represents horizontal distance
y represents vertical distance.

A point is a unit of length. It is a mathametical entity. It has position but no size.

Q Define dot ?

A dot is a physical object, it is not a mathametical object.
→ A dot has a size and we can say it is roughly circular but the size of dot is not defined.
→ Basically the internal surface of the monitor screen is coated with Red, green, blue phosphor meterial, that glows when struct by e⁻ gun. The coated material is arranged into an array of millions of tiny cells Red, green blue. These colored cells are usually called dots.

DOT



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Q3. Define pixel in computer graphics.

Ans Pixel is the basic building block of an image. The pixel is the smallest addressable unit of the screen, which we can control. Each pixel has a name or an address. Basically the word pixel is invented from word picture element.

We can think of a pixel as a logical unit rather than physical unit.

The physical size of a pixel depends on how we have set the resolution for the display screen.

Pixel is also named as PEL.

Q4. Define Resolution and its significance.

Ans → The total count of pixels in any digital image is known as resolution.

- Resolution can be defined in many ways like -
  a) Spatial Resolution
  b) Spectral Resolution
  c) temporal Resolution and
  d) Pixel Resolution

Here we are talking about - pixel Resolution.

→ In pixel resolution, the term resolution refers to the total no. of count of pixels.

for example -

If we say resolution of our screen is M X N then -

M (Width) → total no. of pixels in horizontal direction.

N (Height) → total no. of pixels in vertical direction.

Higher is the pixel resolution, higher is the picture quality, because there are more pixels per inch (PPI), resulting in more pixel information and creating a high-quality, crisp image.

Basically when we change resolution of an Image we are saying how many pixels we want - in each inch of the image.

PPI → pixel per Inch

DPI → Dots per Inch → refers to printer resolution.

Q. Explain Aspect- Ratio?

Ans **Aspect- Ratio :-**

Ratio of horizontal and vertical pixels on the screen is called aspect- Ratio.

Aspect- Ratio is the ratio between width of an Image and height of an Image.

It is mostly explained by two no. seperated by colon (:).

for example → 8:9

It describes relationship between width and height of an Image. expressed as

X : Y.

Advantages of Aspect- Ratio

→ It plays an important role in resizing. during resizing, the aspect- ratio must- remain same in order to keep the image undistorted.

It maintains balance between the appearance of an Image on the screen.

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Aspect Ratio = $\frac{\text{Width}}{\text{Height}} = \frac{\text{Horizontal P.}}{\text{Vertical P.}}$

" The Ratio of the width to the height of an Image".

RASTER SCAN SYSTEM

→ They are most common type of graphics monitor which employs CRT.

→ They are based on television technology.

→ In this e beam sweeps across the screen, from top to bottom covering one row at a time.

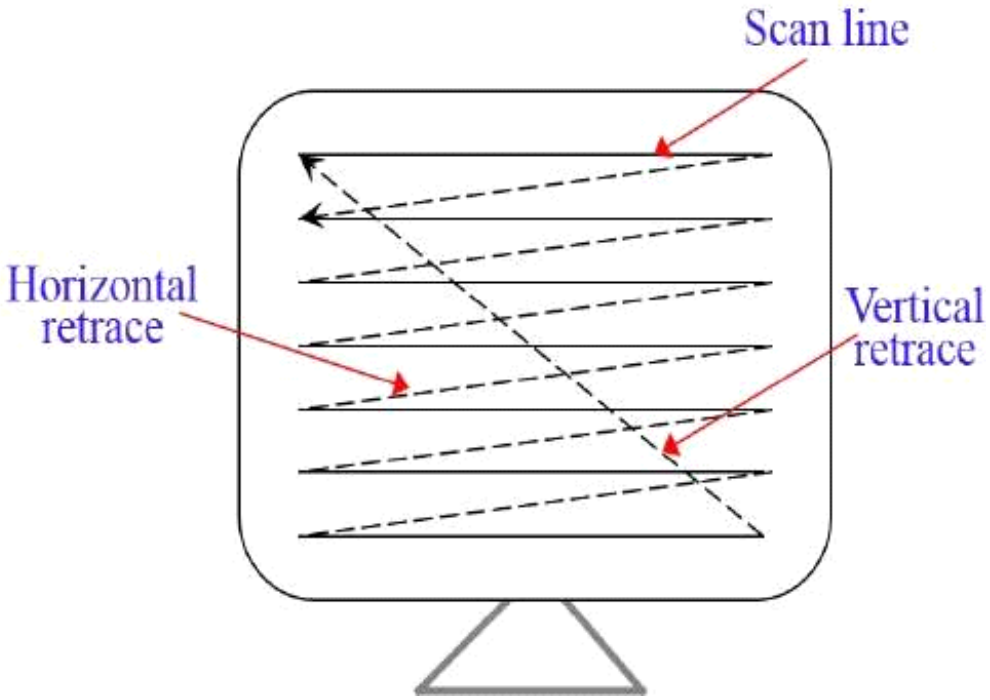
→ A pattern of illuminated ~~pattern of~~ pattern of spot is created by turning beam on and off as it moves across each row.

→ In raster scan system frame buffer is used to keep picture information.

→ Frame buffer holds intensity values for all screen points.

→ Stored values are restored from frame buffer and painted on screen, taking one row at a time.

→ Each screen point is refered as pixel.



RASTER SCAN SYSTEM

→ In Raster scan system refreshing is done at a rate 60-80 frames/

→ At the end of each line e⁻ beam starts to display next line (scan-line) after returning to the left side of screen.

→ The return to the left of screen after refresh of each scan line is also horizontal Retrace of e⁻ beam.

→ At the end of each frame e⁻ beam returns to the top left corner and starts new frame, this is called vertical trace.

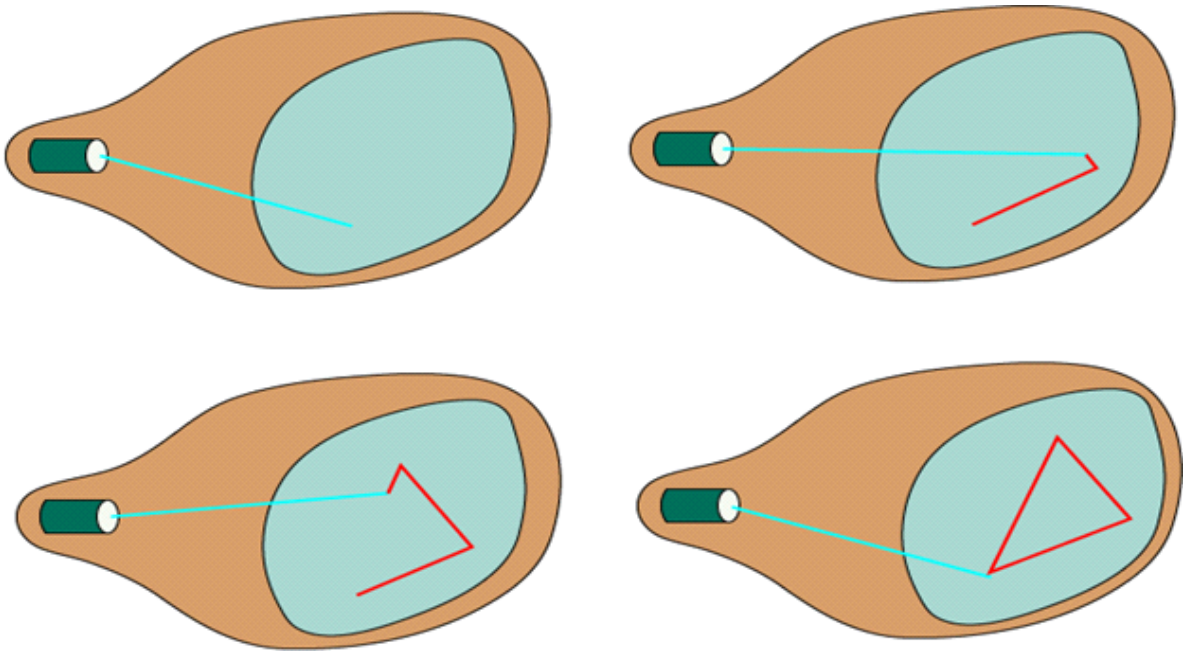
RANDOM SCAN SYSTEM

1) e⁻ beam is directed only to the area of screen where a picture has to be drawn.

2) It is also called vector display because it draws one line at a time.

3) It can refresh component line of a picture in any specified sequence.

4) Display files are used to store picture



RANDOM SCAN SYSTEM

information.

Example - PEN PLOTTER.

Difference between Random scan and Raster scan display

	Random scan	Raster scan
1)	It has high Resolution.	It has low resolution.
2)	It is more expensive	It is less expensive
3)	Any modification if needed is very easy to be done	If modification required, even very difficult to be done.
4)	Solid pattern is difficult to fill	Solid patterns are easy to fill
5)	Refresh rate depends on resolution	Refresh rate does not depend on the picture resolution
6)	Only that part which we want to display is scanned.	Whole screen is scanned.

7	beam penetration technology comes under it.	shadow mask technology comes under this.
8.	It does not uses interlacing method.	It uses interlac
9.	It is good for line drawing Applications.	It is good for realistic displays.

Q. Explain frame buffer and its use.

Ans. A frame buffer is a portion of memory (Random Access memory) which is used to store information of an Image, which has to be displayed.

Generally frame buffer contains bitmap, that drives a video display.

It is a memory buffer containing a complete frame of data.

The information in the frame buffer typically consists of color value for every pixel to be shown on the display.

The color values are common stored in 1-bit binary, 4-bit palet-tize

8 bit- palettized, 16-bit- high color and 24 bit- true color.

OR

In short-

To draw an image, first- we have to place the intensity values for all pixels into an array in our computer's memory. After that- the graphics device can access that- array to determine the intensity at- which each pixel should be displayed.

"The array which contains an internal representation of image is known as frame buffer."

Size of frame buffer depends on size of an image to be drawn.

Q What- is aliasing? write your methods to solve this problem.

OR

what- is anti-aliasing? write solutions for aliasing problem.

Ans Anti-aliasing is a technique used in computer graphics to remove the aliasing effect.

Aliasing

In computer graphics, the process by which smooth curves and other lines become jagged because the resolution of the graphics device or file is not high enough to represent a smooth curve.

In the line drawing algorithms, we have seen that all rasterized locations do not match with the true line and we have to select the optimum raster locations to represent a straight line. This problem is severe in low resolution screens. In such screens line appears like a stair-step, as shown in the figure below. This effect is known as aliasing. It is dominant for lines having gentle and sharp slopes.

The aliasing effect can be reduced by adjusting intensities of the pixels along the line. The process of adjusting intensities of the pixels along the line to minimize the effect of aliasing is called antialiasing.

The aliasing effect can be minimized by increasing resolution of the raster display. By increasing resolution and making it twice the original one, the line passes through twice as many column of pixels and therefore has twice as many jags, but each jag is half as large in x and in y direction.

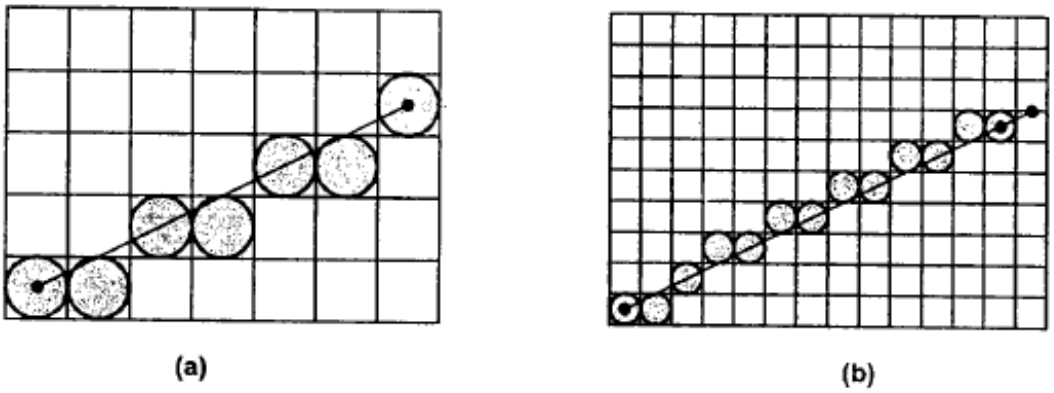


Fig. Effect on aliasing with increase in resolution

As shown in the figure above, line looks better in twice resolution, but this improvement comes at the price of quadrupling the cost of memory, bandwidth of memory and scan-conversion time. Thus increasing resolution is an expensive method for reducing aliasing effect.

With raster system that are capable of displaying more than two intensity levels (colour and gray scale), we can apply antialiasing methods to modify pixel intensities. By appropriately varying the intensities of pixels along the line or object boundaries, we can smooth the edges to lessen the stair-step or the jagged appearance.

Antialiasing methods are basically classified as :-

- Supersampling or Postfiltering:-

Supersampling or Postfiltering is the process by which aliasing effects in graphics are reduced by increasing the frequency of the sampling grid and then averaging the results down. This process means calculating a virtual image at a higher spatial resolution than the frame store resolution and then averaging down to the final

resolution. It is called Postfiltering as the filtering is carried out after sampling.

- Supersampling is basically a three stage process:

1.A continuous image I(x , y) is sampled at n times the frame resolution. This is a virtual image.
2.The virtual image is then lowpass filtered.
3.The filtered image is then resampled at the final frame resolution.

- Area sampling or Prefiltering:-

In this antialiasing method pixel intensity is determined by calculating the areas of overlap of each pixel with the objects to be displayed. Antialiasing by computing area is referred to as Area sampling or Prefiltering. A modification to Bresenham's algorithm was developed by Pitteway and Watkinson. In this algorithm, each pixel is given intensity depending on the area of overlap of the pixel and the line. So, due to the blurring effect along the line edges, the effect of anti-aliasing is not very prominent, although it still exists. For sampling shapes other than polygons, this can be very computationally intensive.