Introduction to Computer Graphics

Course Title: Computer Graphics

Course Code: CSE-413

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Books & Resources to follow

Reference Book(s):

1. Computer Graphics Principle and Practice -- James D Foley, Van Dam
2. Computer Graphics Using Open GL – F S Hill J R
3. OpenGL programming Guide-(Official guide to learning opengl)

Reference websites to follow:-

- https://www.javatpoint.com/computer-graphics-tutorial
- https://www.geeksforgeeks.org/computer-graphics-2/
- https://www.tutorialspoint.com/computer_graphics/index.htm
- https://www.gatevidyalay.com/computer-graphics/

Recommended YouTube playlists:-
https://www.youtube.com/playlist?list=PLMW5djzR9cKMs2_R1c59401IVQOMOs0pr
https://www.youtube.com/playlist?list=PLncy2sD7w4YpWn8jM9Sk6ISOsCZ7oLn9r
https://www.youtube.com/playlist?list=PLrjkTql3jnm9cY0ijEyr2fPdwnH-0t8EY
https://www.youtube.com/playlist?list=PLYwpaL_SFmcAtxMe7ahYC4ZYjQHun_b-T

Outlines Of This Lecture

- Introduction Of Computer Graphics
- Picture, Photo, Image
- Cg Vs Ip
- Application Of Computer Graphics
- Graphics Software
- Types Of Computer Graphics:- Interactive And Passive Graphics
- Introduction To Graphics Systems
- Cathode Ray Tube(crt) Or Refresh CRT
- Operations Of Cathode Ray Tube(crt) Or Refresh CRT
- Properties Of Cathode Ray Tube(crt) Or Refresh CRT
- Pixel Vs Points
- Pixel Resolution
- Pixel Calculation
- Bpp
- Img Size
- Megapixels
- Shades
- Maths
- Aspect Ratio
- What Do You Mean By Aspect Ration 4:3?
- Common Aspect Ratio
- Advantages Of Aspect Ratio
- Aspect Ratio Maths
- Pixel Density Maths

Introduction of Computer Graphics

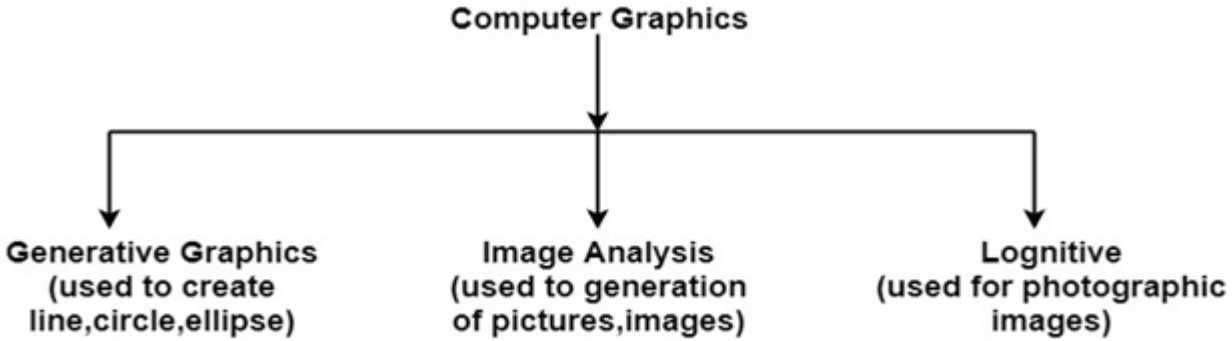
- Graphics are defined as any sketch or a drawing or a special network that pictorially represents some meaningful information. Computer Graphics is used where a set of images needs to be manipulated or the creation of the image in the form of pixels and is drawn on the computer.
- To plot some points on a computer screen to make an image
- Computer graphics involves technology to accept, process, transform and present information in a visual form that also concerns with producing images using a computer
- The study of creating, manipulating, and using visual images in the computer
- An art of drawing pictures, lines, charts etc. on computer screen by using programming is known as computer graphics. The activities involved in computer graphics are computations, creation and manipulation of data. The images are generated and manipulated by a rendering tool known as computer graphics.
- In computer graphics objects are presented as a collection of discrete pixel elements.

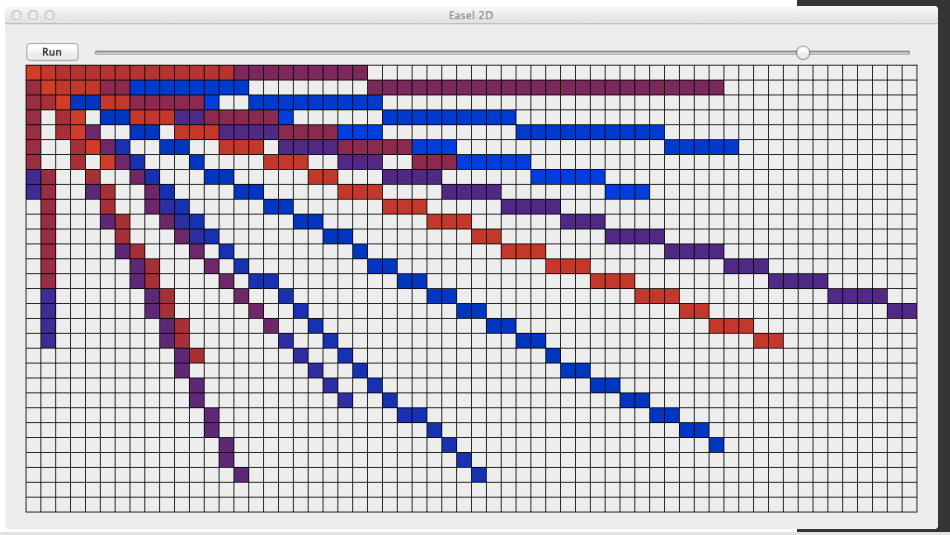
Computer Graphics refers to several things:

•The manipulation and the representation of the image or the data in a graphical manner.

•Various technology is required for the creation and manipulation.

•Digital synthesis and its manipulation.





- **What is a Picture?**
- **Picture** — A drawing, painting, or artwork created on a computer.
- **What is a Photo?**
- **Photo or photograph** — Anything taken by a camera, digital camera, or photocopier.
- **What is an Image?**
- **Image** — Any visual object modified or altered by a computer or an imaginary object created using a computer. A picture that is store in some electronic form. Eg any picture file in your computer.

Computer graphics vs Image Processing

1. CG: generation of picture using computer

IP: technique to modify or interpret existing pictures

2. CG: synthesizes pictures from mathematical or geometrical models

IP: analyze pictures to derive description of objects appeared in the picture

3. CG: creation, storage, manipulation of images of objects

IP: handles image manipulation or interaction.

Application of Computer Graphics

- **Computer graphics user interfaces GUIs**
- – A graphic, mouse-oriented paradigm which allows the user to interact with a computer.
- **Business presentation graphics –** "A picture is worth a thousand words".
- **Cartography –** Drawing maps.
- **Weather Maps –** Real-time mapping, symbolic representations.
- **Satellite Imaging** – Geodesic images.
- **Photo Enhancement** – Sharpening blurred photos.
- **Medical imaging –** MRIs, CAT scans, etc. - Non-invasive internal examination.
- **Engineering drawings –** mechanical, electrical, civil, etc. - Replacing the blueprints of the past.
- **Educational Software:** Computer Graphics is used in the development of educational software for making computer-aided instruction.
- Entertainment – Movies and games.
- **Printing Technology:** Computer Graphics is used for printing technology and textile design.
- **Visualization:** It is used for visualization of scientists, engineers, medical personnel, business analysts for the study of a large amount of information.
- **Typography –** The use of character images in publishing - replacing the hard type of the past.
- **Architecture –** Construction plans, exterior sketches - replacing the blueprints and hand drawings of the past.
- **Art –** Computers provide a new medium for artists.
- **Training –** Flight simulators, computer aided instruction, etc.
- **Simulation and modeling –** Replacing physical modeling and enactments

Graphics software

From sources across the web

- Adobe Illustrator
- Adobe Photoshop
- Canva
- CorelDRAW
- GIMP
- Inkscape
- M 's Paint
- Pixlr
- Affinity Designer

types of graphics: Interactive and Passive Graphics

Computer Graphics can mainly be divided into Interactive (active) and non-Interactive (passive) parts.

• (a) Passive(Non-Interactive) Computer Graphics:

- In non-interactive computer graphics, the picture is produced on the monitor, and the user does not have any controlled over the image, i.e., the user cannot make any change in the rendered image. One example of its Titles shown on T.V.
- Non-interactive Graphics involves only one-way communication between the computer and the user, User can see the produced image, and he cannot make any change in the image.

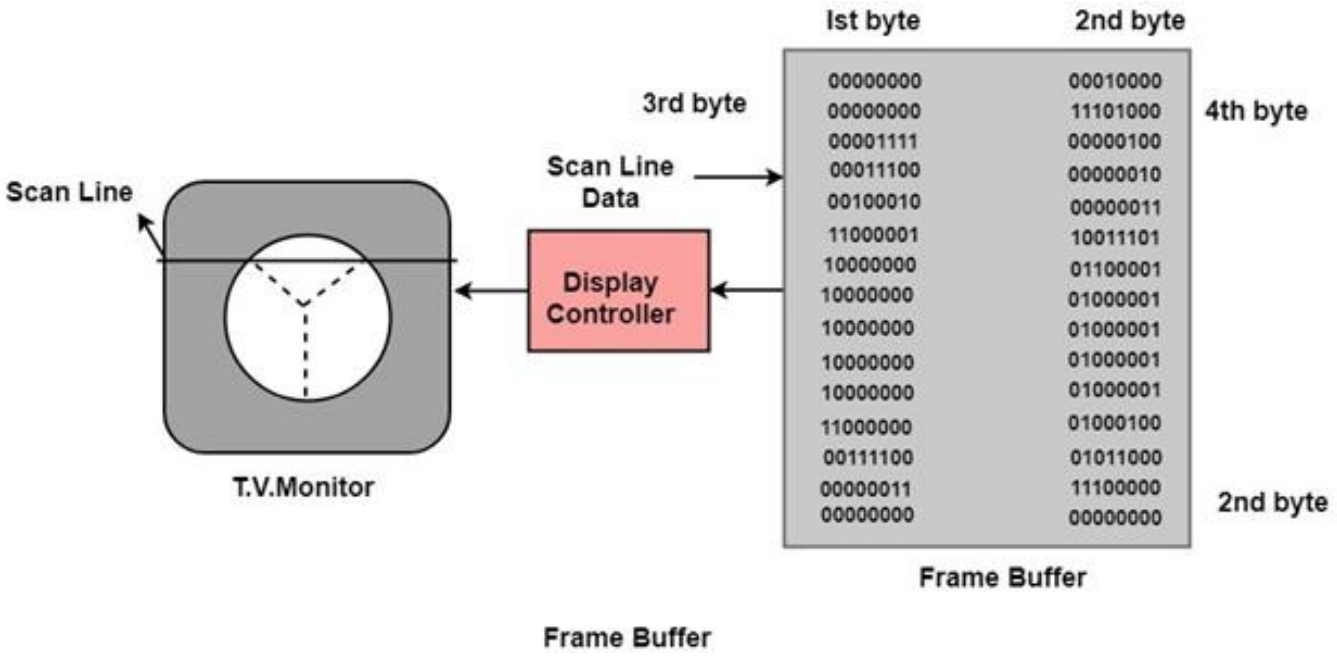
• (b) Interactive Computer Graphics:

- In interactive Computer Graphics user have some controls over the picture, i.e., the user can make any change in the produced image. One example of it is the ping-pong game.
- Interactive Computer Graphics require two-way communication between the computer and the user. A User can see the image and make any change by sending his command with an input device.

Working of Interactive Computer Graphics:

The modern graphics display is very simple in construction. It consists of **three** components:

1. **Frame Buffer or Digital Memory:** A digital frame buffer is large, contiguous piece of computer memory used to hold or map the image displayed on the screen.
2. A **Monitor** likes a home T.V. set without the tuning and receiving electronics.
3. **Display Controller or Video Controller:** It passes the contents of the frame buffer to the monitor.



Introduction to Graphics Systems

With the massive development in the field of computer graphics a broad range of graphics hardware and software systems is available. Graphics capabilities for both two dimensional and three-dimensional applications are general-purpose computers, including many hand-held calculators. On personal computers there is usage of a variety of interactive input devices and graphics software packages; whereas, for higher-quality applications some systems special-purpose graphics hardware and technologies are employed.

Video Display Devices

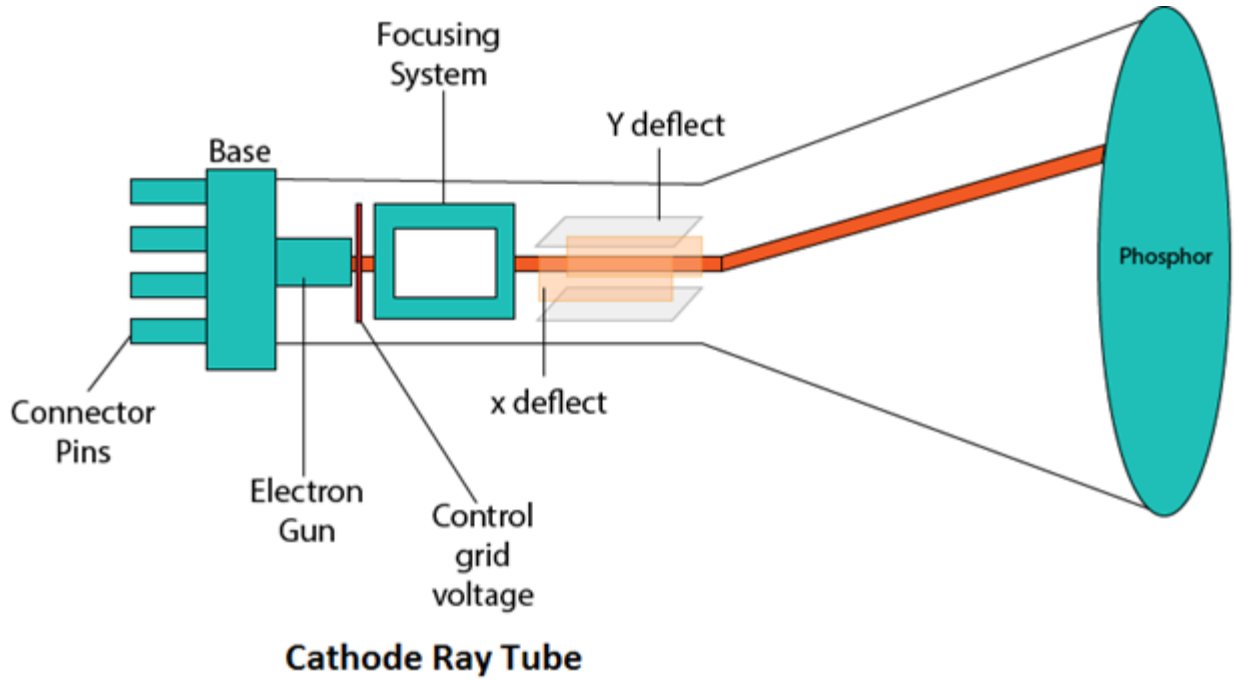
The primary output device in a graphics system is a video monitor. The operation of most video monitors is based on the standard cathode-ray-tube (CRT) design, but several other technologies exist and solid-state monitors may eventually predominate.

Cathode ray tube(CRT) or refresh CRT

- Definition:- Cathode ray tube(CRT) is vacuum tube containing an electron gun and a fluorescent screen to accelerate and deflect the electron beam, used to create images in the form of light emitted from florescent screen.
- The image may represent electrical waveforms(oscilloscope), pictures(tv, monitor), radar targets and others.

- Components of CRT/ operations of CRT:-

1. Electron gun
2. Control grid
3. Heating filament
4. Focusing system
5. accelerating anodes
6. Deflection system
7. Phosphor coated screen



Cathode Ray Tube

→ Properties

CRT:

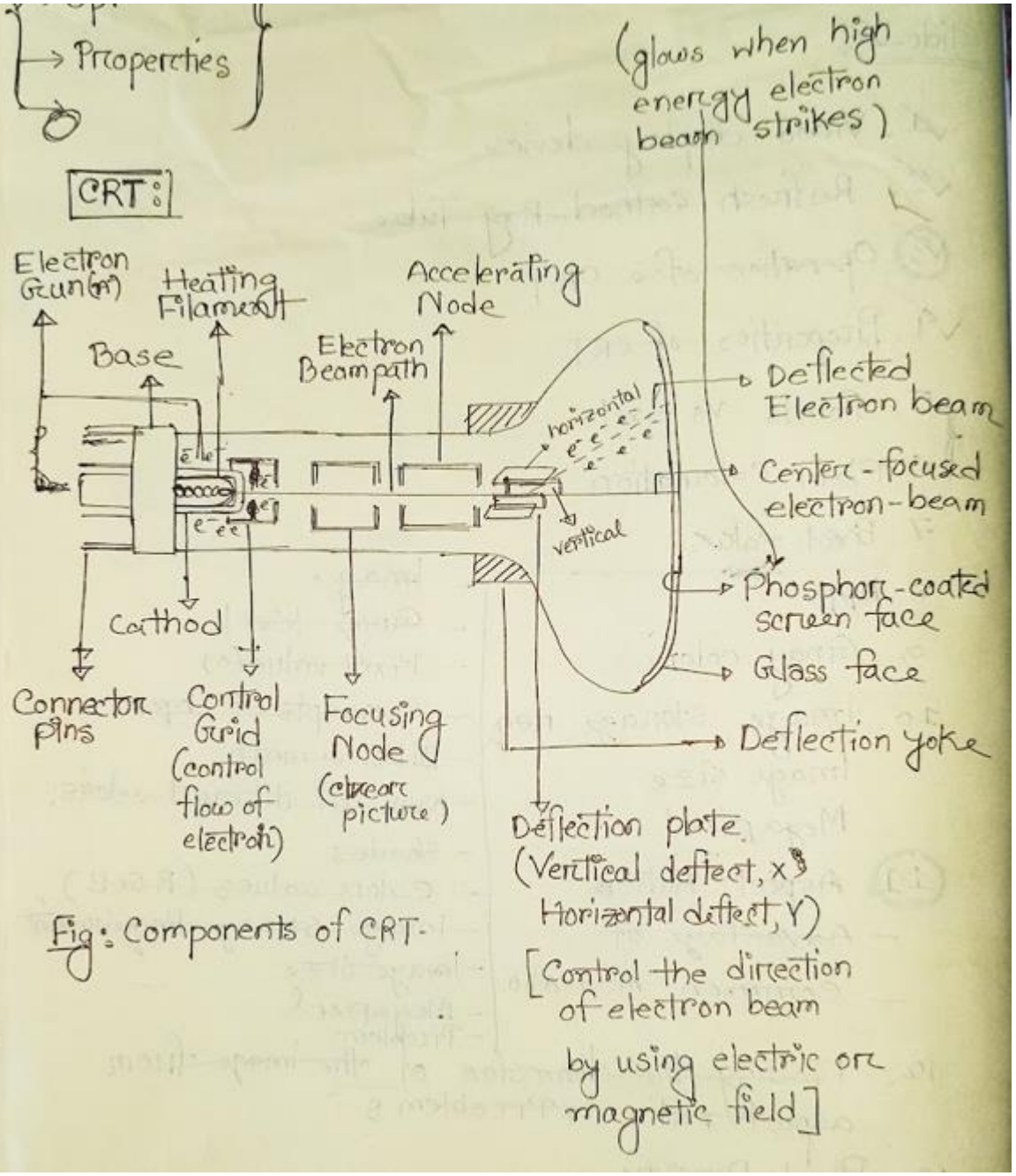


Fig: Components of CRT.

Operation of CRT:

control grid
It consist of ~~cathod~~ & Heating filament.

(1) Electron gun: which emits beams of electron (cathod rays) ~~which are focused into a narrow beam directed at the face of the CRT.~~

The electron beam passes through focusing and deflection systems that direct it towards specified positions on the phosphor-coated screen.

When the beam hits the screen, the phosphor emits a small spot of light at each position. Contacted by the electron beam.

The light, emitted by the phosphor fades very rapidly therefore to keep the picture it is necessary to keep the phosphor glowing. This is achieved through redrawing the picture repeatedly by quickly directing the electron beam back over the same points & the disply using this technique is called refresh CRT.

② Control Grid: Controls the flow of electron (e^-) emitted by the electron gun.

④ Focusing ~~& Accelerating Anodes~~: It is used to create a clear picture by focusing the electrons into a narrow beam. The responsibility of focusing system is to converge electron beam to a small spot where it strikes the phosphor. otherwise the e: will repel each other and the beam would disperse.

⑥ Deflection System: It consist of horizontal & vertical deflection plate. It controls the direction of electron beam by using electric or magnetic field.

⑦⑧ Phosphor-coated screen: It glows when the high-energy electron beam strikes the screen.

3// Heating filament: Heat is supplied to the cathode by directing a current through filament, Heat causes the electrons(e^-) to be boiled off the hot cathode surface.

⑤ Accelerating anode: Negatively charged electron are then accelerated toward the phosphor coating by a high definition positive voltage.

Properties of CRT

1. Persistence

Phosphor is available in different kinds. One variety is available in color but a major issue is their **persistence**. Persistence is defined as the time it takes the emitted light from the phosphor to decay to one-tenth (1/10th) of its original intensity i.e. It means how long they continue to emit light after the electron beam is removed.

Lower persistence phosphors require higher refresh rates to maintain a picture on the screen without flicker. A phosphor with low persistence is useful for displaying highly complex, static pictures. Monitors normally come with persistence in the range from 10 to 60 microseconds.

2. What is meant by refreshing of the screen?

Some method is needed for maintaining the picture on the screen. Refreshing of screen is done by keeping the phosphorus glowing to redraw the picture repeatedly. By quickly directing the electronic beam back to the same points.

3. Refresh Rate

It is the number of time per second the image is redrawn on the screen.

4. Critical Fusion Frequency (CFF)

CFF is the limit of refresh rate above which the picture become steady (fixed).

Or (CFF) is the refresh rate (number of image redraws per second) at which the image stops flickering and fuses into a steady image.

5. Horizontal Scan Rate

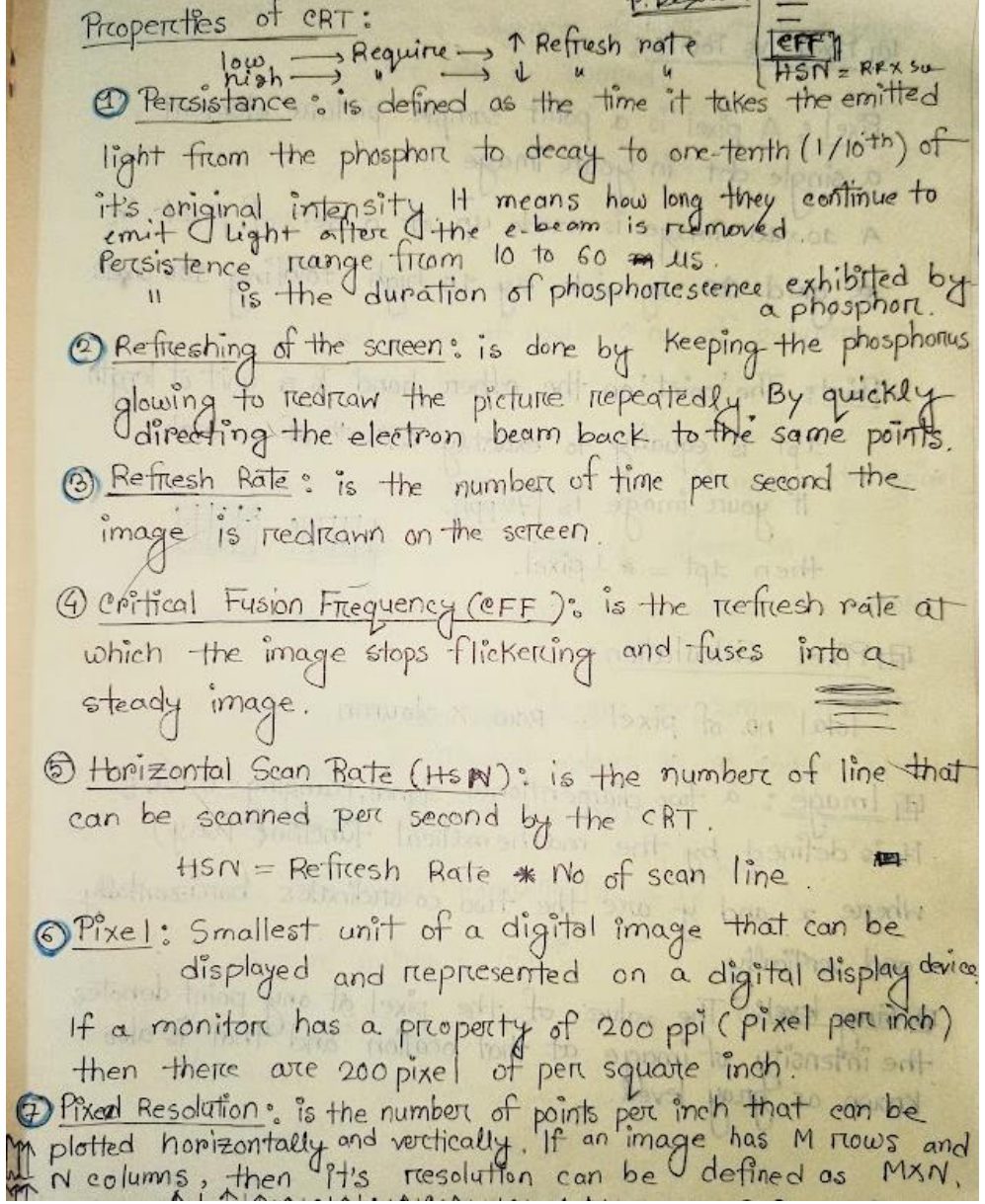
It is the number of line that can be scanned per second by the CRT.

HSN= Refresh Rate * No of scan line

6. Pixel

A pixel or PEL (short for picture element (picture + element), using the common abbreviation "pix" for "picture") is one of the many tiny dots that make up the representation of a picture in a computer's memory. Each such information element is not really a dot, nor a square, but an abstract sample or it is the smallest unit of a digital image or graphic that can be displayed and represented on a digital display device.

If a monitor has a property of 200 ppi (pixels per inch), then there are 200 pixels in any given area of per square inch. Meaning, it'll display a 200x200 image in a square inch. If it has 400 ppi, it'll display the same image in half a square inch.



Pixel vs Points:

Pixel: A pixel is a point sample 'picture element', a single dot in your image.
A 10x10 image is made up of a set of pixels in a grid 10 by wide by 10 high, totaling 100 pixels.

Point: The 'point' on the other hand is a unit of length. 1pt is equally to exactly 1/72th of an inch.
If your image is [72ppi].
then 1pt = 1 pixel.

Pixel Calculation:

Total no. of pixel = Row x column

Image: a two diamentional signal, ranging: 0-255
It is defined by the mathematical function f(x,y)
where x and y are the two co-ordinates horizontally and vertically.

Gray level: The value of the pixel at any point denotes the intensity of image at that location and that is also known as gray level.

7. Pixel Resolution

The maximum number of pixels (that can be uniquely identified) on a CRT without overlapping is referred to as the **resolution**. A more precise definition of resolution is the number of points per inch that can be plotted horizontally and vertically, although it is often simply stated as the total number of points in each direction. For example. If an image has M rows and N columns, then its resolution can be defined as M X N.

If we define resolution as the total number of pixels, then pixel resolution can be defined with set of two positive numbers where the first number is the number of pixel columns (width) and the second is the number of pixel rows (height).

We can say that the higher is the pixel resolution, the higher is the quality of the image.

We can define pixel resolution of an image as 800 X 600 or 800 by 600.

Concept of Bits Per Pixel

bpp or bits per pixel denotes the number of bits per pixel. The number of different colors in an image is depends on the depth of color or bits per pixel.

Bits in mathematics:

It's just like playing with binary bits.

How many numbers can be represented by one bit?

0

1

How many two bits combinations can be made?

00

01

10

11

If we devise a formula for the calculation of total number of combinations that can be made from bit, it would be like this.

$$(2)^{bpp}$$

Where bpp denotes bits per pixel. Put 1 in the formula you get 2, put 2 in the formula, you get 4. It grows exponentially.

Number of different colors:

Now as we said it in the beginning that the number of different colors depend on the number of bits per pixel.

Pixel value(0): 0 = means absence of light, that is black color will be formed.

o o o
o o o
o o o

Total no. of pixel = no. of rows x no. of columns
= 3x3
= 9

It means that an image would be formed with 9 pixel and that image would have a dimension of 3 rows and 3 column and image would be black.

Concepts of Bit's Per Pixel: bpp denotes the number of bit's per pixel. The number of different colors in an image is depends on the depth of color or bpp.

Formula for color combination = $(2)^{bpp}$

Shades = number of colors = $(2)^{bpp}$

Color images are usually of the 24 bpp or 16bpp format.

Black color denoted by = 0

White " " " = $(2)^{bpp} - 1$

In case of 1 bpp - 0 denotes black
1 " white

In case of 8 bpp 0 denotes black
255 " white

Gray scale: bpp = 8 → 2^8 = 256 colors

Gray color is the midpoint of black & white.

Image size: The size of an image depends upon the things :-

- Number of rows
- " " columns
- " " bit's per pixel

Formula to calculate image size = rows x columns x bpp

example-1: Assume a picture has 1024 rows and it has 1024 columns.

Size of an image = rows x cols x bpp
= 1024 x 1024 x 8
= 8388608 bits
= 8388608/8 = 1048576 bytes
= 1048576/1024 = 1024 Kb
= 1024/1024 = 1 Mb.
= 1Mb

Megapixels : $\frac{\text{Column pixels (width)} * \text{row pixels (hight)}}{1 \text{ Million } (10^6)}$

examples: # image of diamension = 2500 X 3192

So, pixel resolution = 2500 * 3192

= 7980000 bytes

Resolution = (col x row) bytes or pixels $= \frac{7980000}{1000000}$

M. pixel $= \frac{\text{Resolution}}{10^6}$ $= 7.98$

$\cong$ 8 mega pixel (approximately)

Megapixels

We can calculate mega pixels of a camera using pixel resolution.

Column pixels (width) X row pixels (height) / 1 Million.

The size of an image can be defined by its pixel resolution.

Size = pixel resolution X bpp (bits per pixel)

Lets say we have an image of dimension: 2500 X 3192.

Its pixel resolution = 2500 * 3192 = 7980000 bytes.

Dividing it by 1 million = 7.98 = 8 mega pixel (approximately).

Shades

You can easily notice the pattern of the exponential growth. The famous gray scale image is of 8 bpp, means it has 256 different colors in it or 256 shades.

Shades can be represented as:

$$\text{Shades} = \text{number of colors} = (2)^{bpp}$$

Color images are usually of the 24 bpp format, or 16 bpp.

Problems:

1. **What do you mean by resolution 800 X 600?**

   800 x 600 resolution means the device can show 800 pixels across by 600 pixels down. In total, this screen displays 480,000 pixels.

2. **How many pixels for a 3 X 2 inch image at a resolution of 300 pixels per inch?**

   There are a total of (3 X 300) X (2 X 300) = 900 X 600 or 540000 pixels.

3. **Compute the size of a 640 X 480 image at 96 pixels per inch or how can measure a 640 X 480 image at 96 pixels per inch?**

   A 640 X 480 image would measure 640/96 by 480/96 = $6\frac{2}{3}$ inches by 5 inches.

4. **Compute the ~~resolution~~** pixels per inch **of a 2 X 2 inch image that has 512 X 512 pixels.**

   512/2 = 256 pixels per inch.

5. **Compute the ~~resolution~~** pixels per inch **of a 3 X 2 inch image that has 900 X 600 pixels.**

   900/3 or 600/2 = 300 pixels per inch.

Aspect Ratio: It is the ratio of vertical points to horizontal points necessary to produce equal-length lines in both directions on the screen. That is, it is the ratio between width of an image and the height of an image. It is commonly explained as two numbers separated by a colon (8:9) or a forward slash (3/4). This ratio differs in different images, and in different screens.

An aspect ratio of 3/4 means that a vertical line plotted with three points has the same length as a horizontal line plotted with four points. For instance, a 6 x 4 inch image has an aspect ratio of 3:2.

Def^n 2: An *aspect ratio* is a proportional relationship between an image's width and height. Essentially, it describes an image's shape. Aspect ratios are written as a formula of width to height, like this: **3:2**. For example a 4:3 aspect ratio means that the every 4 units of width there are 3 units of height, i.e. the object is 1.33 (4/3) times wider than it is high.

For example, a square image has an aspect ratio of 1:1, since the height and width are the same. The image could be 500px × 500px, or 1500px × 1500px, and the aspect ratio would still be 1:1.

As another example, a portrait-style image might have a ratio of 2:3. With this aspect ratio, the height is 1.5 times longer than the width. So the image could be 500px × 750px, 1500px × 2250px, etc.

dpi → (dot's per inch)

$A.R. = \frac{Col\,(width)}{Row\,(height)}$

Aspect Ration : Ratio of width to height of device

- It is the ratio of vertical points to horizontal point's necessary to produce equal-length lines in both direction on the screen.
- An aspect ratio is a proportional relationship between an image's width and height.
- Essentially, it describes an image's shape.
- It is commonly explained as two numbers seperated by a colon(:) or a forward slash(/).

What do you mean by aspect ratio 4:3? (TV, monitor, digital cam)

For every 4 unit of width (column),
there are 3 " " height (row).
i.e. the object is 1.33 (4/3) times widther than it is high.
So, the image could be: 400px X 300px
600px X 450px
1000px X 750px

What do you mean by aspect ration 1:1 ?

It means that for every 1 unit's of ~~height~~ width (column)
there are 1 unit's of height (row).

So the height & width are same.

So the image could be : 500px X 500px
1500px X1500px
300px X 300px

commonly used in print photographs, mobile screens, social media platforms.

What do you mean by aspect ratio 2:3 ?

It means that for every 2 unit of ~~height~~ width (col)
there are 3 " " height (row)

The image is 1.5(3/2) time higher than ~~it is~~ width.

So, the image could be : 500px X 750px
1500px X 2250px

Common Aspect Ratios. social media

1:1 ——— used for print photograph, mobile screen.
3:2 ——— used for print sizes
4:3 ——— TV, pc monitor, Digital cams.
16:9 ——— used in presentation slide, computer monitor or widscreen TVs.

Advantage of Aspect Ratio :

(1) maintain a balance between the appearances of an image on the screen.

(2) maintain a ratio between horizontal and vertical pixel.

(3) It does not let the image to get distorted

(4) when the aspect ratio is increased that is ~~qu~~ the quality remains the same.

original Image

smaller image, but with same balance.

Common Image Sizes for Web

1920px × 1080px (16:9 ratio)	– HDTV Format – Presentation – Social media cover images
1280px × 720px (4:3 ratio)	– HD Format – seen in photography and film (digital Camera) – Computer monitors
1080px × 1080px (1:1)	– Social media post & Profile picture ratio – mobile screen – Print photographs

Common photograph sizes

4x6 or 5x7 inches	Standard photography sizes
8 x 10 inches	Portraits & Larger art prints
8.5 x 11 inches	Flyer size for events and ads
12x18 or 18x24 inches	stan-dard poster size
24 x 36 inches	Displaying outdoor ads

These are some of the most common image sizes for web.

1920x1080 px	HDTV format, presentations, social media cover images. 16:9 ratio.
1280x720 px	HD format, seen in photography and film. 4:3 ratio.
1080x1080 px	Social media posts and profile pictures. 1:1 ratio.

4x6 or 5x7 inches	Standard photography sizes
8x10 inches	Portraits and larger art prints
8.5x11 inches	Flyer size for events and ads
12x18 or 18x24 inches	Standard poster sizes
24x36 inches	Displaying outdoor ads

Finding the dimensions of the image from aspect ratio:

Aspect ratio tells us many things. With the aspect ratio, you can calculate the dimensions of the image along with the size of the image.

For example

If you are given an image with aspect ratio of 6:2 of an image of pixel resolution of 480000 pixels given the image is an gray scale image.

And you are asked to calculate two things.

- Resolve pixel resolution to calculate the dimensions of image
- Calculate the size of the image

Solution:

Given:

Aspect ratio: c:r = 6:2

Pixel resolution: c * r = 480000

Bits per pixel: grayscale image = 8bpp

Find:

Number of rows = ?

Number of cols = ?

Solving first part:

Equation 1. $c:r = 6:2 \rightarrow c = 6r / 2$

Equation 2. $c = 480000/r$

Comparing both equations $\rightarrow \frac{6r}{2} = \frac{480000}{r}$

$$r^2 = \sqrt{\frac{480000 \cdot 2}{6}}$$

That gives $r = 400$.

Put r in equation 1, we get $\rightarrow c = 1200$.

So rows = 400 cols = 1200.

Solving 2nd part:

Size = rows * cols * bpp

Size of image in bits = 400 * 1200 * 8 = 3840000 bits

Size of image in bytes = 480000 bytes

Size of image in kilo bytes = 48 kb (approx).

Problems:

1. What is the aspect ratio for a 2 X 2 inch image, 512 X 512 image, 6 X $4\frac{1}{2}$ inch image and 1024 X 768 image?

   For a 2 X 2 inch image = 2/2= 1/1 (1:1)

   For a 512 X 512 image = 512/512 = 1/1 (1:1)

   For a 6 X $4\frac{1}{2}$ inch image = 6/ $4\frac{1}{2}$ = 4:3

   For a 1024 X 768 image = 1024/768 = 4/3 or 4:3

2. If an image a height of 2 inches and an aspect ratio of 1.5, what is its width?

   We know,

   Aspect ratio = width/ height

   or, width= aspect ratio X height

   = 1.5 X 2

   = 3 inches

3. If we want to resize a 1024 X 768 image to one that is 640 pixels wide with the same aspect ratio, what would be the height of the resized image?

   We know,

   Aspect ratio = width/ height

   or, 1024/768 = 640/ height

   or, height = (640 X 768)/ 1024 pixels

   = 480 pixels

Pixel Density: It refers to how close the pixels are placed on the screen or display. It is measured in PPI (Pixel Per Inch).

PPI means the number of pixels present per inch on the display or screen.

Pixel density and PPI depend on both the screen size and the screen resolution.

PPI can be calculated by the following 2 steps:

1) Calculating the diagonal size in pixels (dp) using pythagoras theorem

$$dp = \sqrt{(hp)^2 + (wp)^2}$$

where
dp = diagonal size in pixels
hp = height " " "
wp = width " " "

2) Dividing the diagonal size in pixels (dp) by diagonal size in inches (di)

$$PPI = \frac{dp}{di}$$

di = diagonal size in inches

Example-1: For a 5.5 inch screen with 1920 x 1080 pixels resolution we get:

$$dp = \sqrt{(1920)^2 + (1080)^2} = 2202.91$$

Here
$wp = 1920$
$hp = 1080$

$$\therefore PPI = \frac{dp}{di} = \frac{2202.91}{5.5} = 400.53$$

So for a 5.5 inch screen with 1920 x 1080 pixels resolution we get a PPI of 401 (400.53 is rounded off to 401)

Example-2: For a 5 inch screen with 1920 x 1080 pixels resolution we get:

$$dp = \sqrt{(1920)^2 + (1080)^2} = 2202.91$$

$$PPI = \frac{dp}{di} = \frac{2202.91}{5} = 440.58 \simeq 441.$$

Example-3: Calculate the dots or pixels per inch (PPI) of a 50" high definition TV (1920 x 1080) that has aspect ration of 16:9.

Ans:

$$PPI = \frac{dp}{di} = \frac{\sqrt{(1920)^2 + (1080)^2}}{50} = \frac{2202.91}{50}$$

$$= 44.06$$

So, dots or pixels per inch (PPI) or pixel density is 44.06

Example-4: What is the pixel density (PPI - pixel per inch) of a 40 inch full HD (1920 x 1080) TV screen?

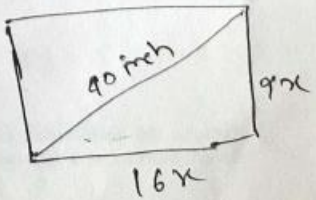
Ans:

$$dp = \sqrt{(1920)^2 + (1080)^2} = 2202.91$$

$$PPI \text{ (pixel density)} = \frac{dp}{di} = \frac{2202.91}{40}$$

$$= 55.07$$

Example-5: Find the width and height of a 90 inch full HD (1920 × 1080) TV screen.



Am: So its aspect ration will be $\frac{1920}{1080}$

$= \frac{16}{9}$

Let width $= 16x$ and height $= 9x$

According to pythagoras theorem,

$(16x)^2 + (9x)^2 = (90)^2$

$\Rightarrow 337x^2 = 1600$

$\Rightarrow x^2 = \frac{1600}{337}$

$\therefore x = \sqrt{\frac{1600}{337}} = 2.17893$

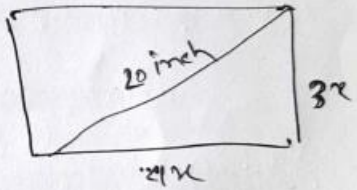
Now width $= 16x = 16 \times 2.17893 = 34.863$ inch

height $= 9x = 9 \times 2.17893 = 19.61$ inch

Example-6: Find the width and height of an older 20 inch TV whose screen has an aspect ration of 4:3.

Am: Here Let width $= 4x$

height $= 3x$



According to pythagoras theorem,

$(4x)^2 + (3x)^2 = (20)^2$

$\Rightarrow 16x^2 + 9x^2 = 400$

$\Rightarrow 25x^2 = 400$

$\Rightarrow x^2 = \frac{400}{25}$

$\Rightarrow x = \sqrt{\frac{400}{25}} = \sqrt{16} = 4$

$\therefore$ Width $= 4x = 4 \times 4 = 16$ inch

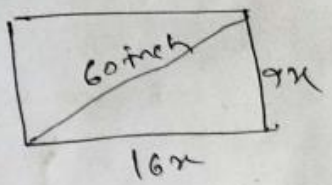
Height $= 3x = 3 \times 4 = 12$ inch

Addition, area of the TV $= 16 \times 12$ (L×W)

$= 192$ square inch

Example-7: Find the width & height of a newer 60-inch TV whose screen has an aspect ratio of 16:9.

Ans: Let width = 16x & height = 9x



According to pythagorean,

$$(16x)^2 + (9x)^2 = (60)^2$$

$$\Rightarrow 337x^2 = 3600$$

$$\Rightarrow x^2 = \frac{3600}{337} = \sqrt{\frac{3600}{337}} = 3.268$$

$\therefore$ width = 16x = 16 × 3.268 = 52.3 inch

height = 9x = 9 × 3.268 = 29.4 inch.

and area = 52.3 × 29.4 = 1537.62 square inch

Example-8: A wide-screen TV has an aspect ratio of 16:9. Find the length of a diagonal on a wide-screen TV that has a height of 25.2.

Ans: Given the wide-screen TV has the aspect ratio: $\frac{16}{9}$ and the height is 25.2

Let L be the length and W be the width

$\therefore L = 25.2$

Now, we can write, $\frac{W}{L} = \frac{16}{9}$

$$\Rightarrow W = \frac{16L}{9} = \frac{16 \times 25.2}{9} = 44.8$$

According to the pythagorean theorem,

$$\text{diagonal} = \sqrt{(44.8)^2 + (25.2)^2} = 51.40$$

(Ans)

Addition, width & the TV = 44.8 × 25.2

= 1128.96 square inch