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Factual to Virtual Visualization

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Abstract*: The purpose of this study is to explore the formation of image output in computer system from the user input information. The study seeks to answer the research question How does the image displayed on the computer screen and how appearance of image changed? The goal is to analyze transformation of real world picture to computerized output image in a very simple method by explaining all major components involved in this process in detail with diagrams. Further by using some mathematical concepts algorithms are derived and implemented to transform the images to change their shapes, sizes etc As there is a very near context between computer science and mathematics. Systems works completely based on the algorithms written to perform the particular task, algorithms are designed based on the mathematical concepts and are implemented by the programming languages in computer.*

Paper concentrates on the graphic capabilities and potentials of the digital computer. It presents an abstract idea of system that, how computer works internally to create and represent the simple graphical elements and images which human can see and understand. Paper presents all the components and related concepts with suitable examples from input information to graphical output produced by computer. After by getting the concept of image formation the next step is to know that how transformation of image takes place by changing original image. This paper illustrates four types of transformations with example translation, rotation, scaling, and shearing.

Paper explores about display devices, different types of display methods, programming tools and finally drawing of a simple line in computer screen using a simple line drawing algorithm. Further it elaborates the concept of pixels, resolution, aspect ratio, persistency, different types of transformations etc.,

Keywords: Display devices(CRT), Resolution, Aspect ratio, Persistency, Gray scale display, Color display, Raster scan, Random scan, Drawing objects, Painting methods, Digital Differential Algorithm, transformations, scale, shear, rotation, translation.

I. INTRODUCTION

Conveying information in terms of graphics as a supplement to or instead of written descriptions, and the utilization of computers to accomplish such tasks leads to a new discipline of computer graphics. Creating an abstract realistic images has been a major focus in the study of computer graphics. In computer vision, you take pictures of the world and turn them into abstract representations that the computer can understand. The paper title “Factual to Virtual Visualization” focus on two terms factual and virtual, factual is the real world object, it is three dimensional in reality which can be mapped to the computer screen virtually which is of two dimensional. Here virtual is the concept that one can feel it is the real picture in computer, but it is an abstract view or an illusion of the real picture.

"A picture is worth a thousand words", today it is revised as "A computer is a worth of billion pictures". Graphics in computer is the field of visual computation, where one utilizes the computers both to generate visual images analyse and synthesize or alter visual and special information sampled from the real world.

This paper presents a background task performed in computer system to transform the real world picture to atomized form. There are many hardware devices and software modules to convert an input of user into the graphical output. Some of the important components are display devices, display methods, drawing tools etc. output quality of an image is depending on the properties like resolution, aspect ratio, persistency, pixel size, buffer area etc. by coordinating and cooperating these hardware and software components the processing of image takes place.

Finally pixel wise formation of line in computer system is illustrated with DDA algorithm. Point is one of the most important graphic primitive, Line drawing is performed by collecting number of points between the initial and final coordinate values given by user. Different cases of algorithms are derived mathematically by using the line drawing

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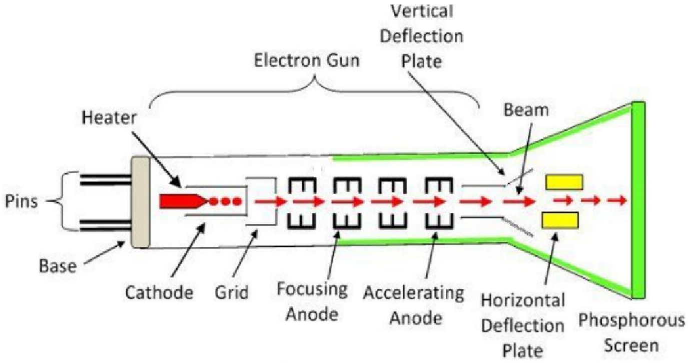
formula y=mx+c and the scan converted into computer image. To illustrate transformation of images rotation, translation, scaling, shearing are explained with diagrams and suitable examples to change place size, shape, and location respectively.

II. METHODOLOGY

Initially picture information stored in buffer area in terms of binary (0's and 1's) and are retrieved and processed. The picture information given through the stream of electrons and its flow is controlled by the display controller finally the controlled electrons flow produces illuminations on the screen of the display device and the image is formed. In this process the important components and their description with examples are explained as follows.

Cathode Ray Tube: is a technology that is used widely in the traditional televisions and screens. An image is created on the screen on Cathode Ray Tube.



The electron gun generates an electron beam of high intensity when it is connected to high voltage. Electronic beams are attracted by the phosphor coated screen as it is positively charged. When the electron beam emits from the electron gun, electrons are dispersed in all directions this is controlled by control grid and makes these electrons to pass through the small hole as an electron beam. Further electron beam passes through a pair of electrostatic and magnetic deflection coil which is on the neck of the electron gun. These coils are responsible for the horizontal and vertical movement of the beam. An accelerating anode push electron beam towards screen and focusing 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. It redraws the picture by directing the electron beam back over the same screen points quickly this is called refreshing.

Image created at a
low resolution of 72 dpi.

Image created at a
high resolution of 350 dpi.

An image that is presented on the computer screen is made up of pixels. The screen consists of a rectangular grid of pixels, arranged in rows and columns. The pixels are small enough that they are not easy to see individually. In fact, for many very high-resolution displays, they become essentially invisible. If the size of pixel is more, then the low quality picture formed. As the size of pixel is small high quality picture are formed. The quality of an image depends on 3 components as follows

Resolution: Resolution is a measurement of the number of pixels per inch without overlap. Distance from one pixel to another forms an image resolution. i.e, the resolution of an image is the total number of pixels along with the entire height and width of the image.

Example: A full-screen image with a resolution of 1000×800 dpi means that there are 1000 columns of dot pixels per inch and each column comprises 800 dot pixels per inch.

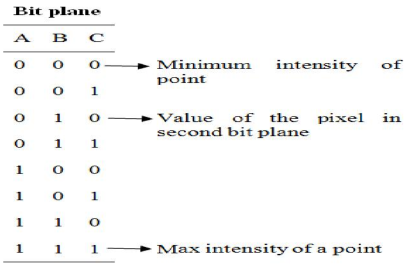
A total of 1000×800 = 800000 dot pixels in sq. inches image area.

Similarly Screen resolution is the number of pixels on a screen, both horizontally and vertically.

Aspect ratio : Aspect ratio is the ratio of the vertical points to horizontal points representing relationship between an image's width and height, it describes an image's shape.

For example, an image with the resolution 1024X768 has a resolution is 1024*768=786432, and aspect ratio would be 4:3.

Persistency power : 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 phosphors require higher refresh rates to maintain a picture on the screen without flicker.



Bit plane

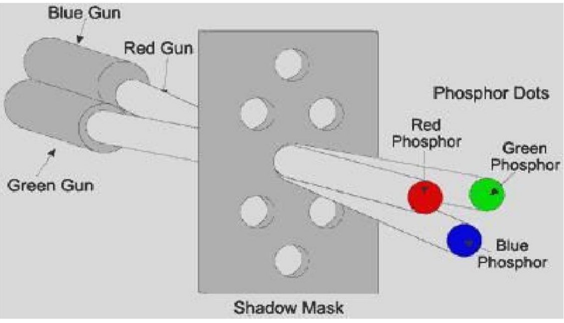
A	B	C	
0	0	0	──► Minimum intensity of point
0	0	1	
0	1	0	──► Value of the pixel in second bit plane
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	──► Max intensity of a point

Each pixel contains one or more bits of information, depending on the degree of detail in the image. For example, a black-and-white image contains only one bit per pixel (a binary bit can be in one of two states; thus, a single bit can represent white or black). Typically, 256 shades of gray are used. Here the picture information is stored in the form of bit planes(on each bit plane full information of picture is stored) and for brightest intensity 3 bit plane should have 1 as respective information in the frame buffer and for least intensity it is 0. Some of the intensity combinations in black and white image is as shown in table.

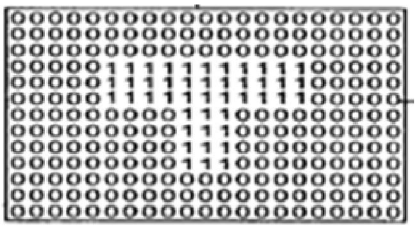
Shadow-mask methods are commonly used for color image in raster scan systems because they produce a much wider range of colors. A shadow-mask CRT has three phosphor color dots at each pixel position. One phosphor dot emits a red light, another emits a green light, and the third emits a blue light. This type of CRT has three electron guns, one for each color dot, and a shadow-mask grid just behind the phosphor-coated screen. The 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.

e image

Color variations in a shadow-mask CRT is due to 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. Other combinations of beam intensities produce a small light spot for each pixel position, since our eyes tend to merge the three colors into one composite. The color we see depends on the amount of excitation of the red, green, and blue phosphors. A white (or gray) area is the result of activating all three dots with equal intensity.



An image with shading and color commonly contains 24 bits of information to provide more than 16 million, possible states per pixel, known as "true color," 24-bit color can realistically depict color images. The number of bits stored in each pixel is known as the color depth. Where a color can be specified by three 8-bit numbers, giving the levels of red, green, and blue in the color, for example, the file size of a graphics of 360x216 pixels and 256 colors will be 360 x 216 x 8 bits = 77,760 bytes. Any color that can be shown on the screen is made up of some combination of these three "primary" colors. The quality of picture highly based on resolution, persistency power and aspect ratio



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Picture information storedin Frame buffer(Refresh buffer)

In any case, the color values for all the pixels on the screen are stored in a large block of memory known as a frame buffer. Frame buffer is storage area in raster scan display system is arranged as a two dimensional table. Every row column entry stores information such as brightness or color value of the corresponding pixel on the screen. Changing the image on the screen requires changing color values that are stored in the frame buffer. The screen is redrawn many times per second, so that almost immediately after the color values are changed in the frame buffer, the colors of the pixels on the screen will be changed to match, and the displayed image will change.

There are two types of display techniques raster scan and random scan

III. RASTER-SCAN TECHNIQUE

The architecture consists of display controller, central processing unit, video controller, refresh buffer, keyboard, mouse and CRT. Combination and coordination of all these component to form the particular output is as shown in figure-1.

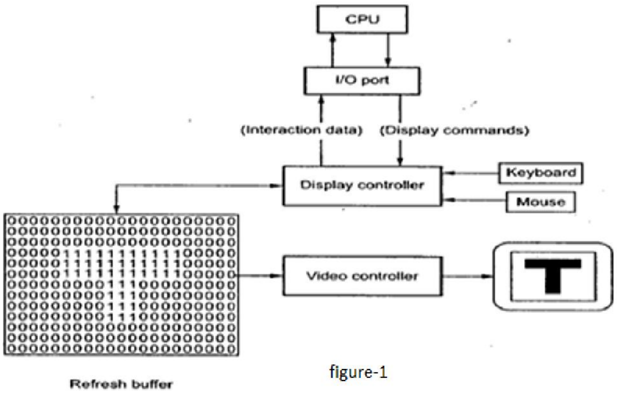
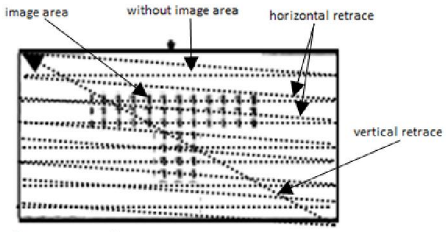


figure-1



formation of image in raster scan system

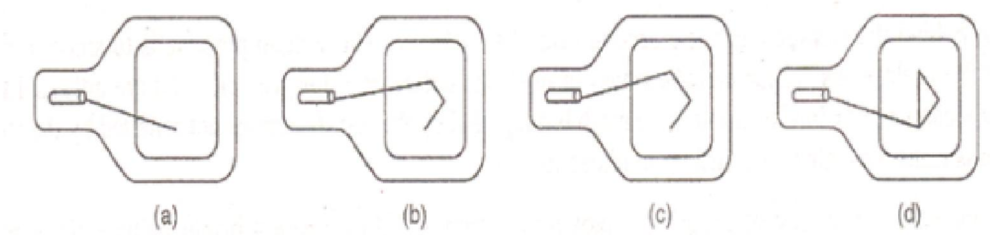
figure-2

In raster scan electronic beam is swept across the screen from left top corner to bottom right corner line by line, swapping from left to right is called horizontal retrace and when beam reached to bottom right corner it redirects to left top corner is called vertical retrace as shown in the figure-2. While swapping the pixel value gets on and off by showing with image area and without image area respectively. This scanning process is called refreshing. Each complete scanning of a screen is normally called a frame. Raster scan is most common method of displaying images on the CRT screen.

As shown in the figure-1, the display image is stored in the form of 0s and 1s in the refresh buffer. The video controller reads this refresh buffer and produces the actual image on screen.

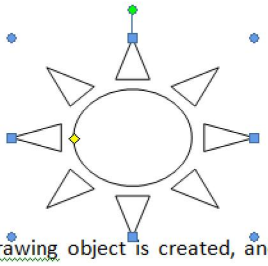
3.1 Random Scan Display Technique

The random scan display is also called as vector scan display as the picture formation is line wise. It is a technique in which the image is formed through an electron beam, which is directed only to the specific areas of the screen where the image is to be drawn. The resolution of the random scan display is high, and thus it delivers smooth realistic image drawing. Vector graphics are designed with curved points and lines which create a clean, infinitely scalable picture when combined in vector artwork. Vector graphics are based on mathematical formulas rather than square pixels, allowing for a crisper display. Formation of image in random scan is as shown in the figure, electronic beam rendered through the line and image formed line by line.

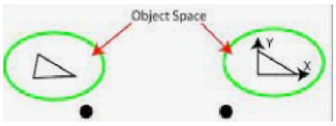


Two categories of programs that can be used to create images: painting programs and drawing programs. In a painting program, the image is represented as a grid of pixels, and the user creates an image by assigning colors to pixels. This might be done by using a "drawing tool" that acts like a painter's brush. Painting functions don't create objects. If you look at a computer screen, you will see that it is made up of millions of tiny dots called pixels. A paint function changes the color of individual pixels based on the tools you choose. For example in a photograph of a person's face the colors changes gradually because of light, shadow and complexion.

In a painting program, the image is represented as a grid of pixels



drawing object is created, and it can be resized, reshaped and moved using nudge points



translation transformation

In a drawing program, the user creates an image by adding and combining geometric shapes, and the image is represented as a list of shapes. You should be able to select one of the shapes in the image and move it or change its size, so drawing programs offer a rich set of editing operations that are not possible in painting programs. (The reverse, however, is also true.)

Drawing is a software application means using tools that create objects such as squares, circles, lines or text, which the program treats as discrete units. If you draw a square in PowerPoint, for example you can click anywhere on the square and move it around or resize it. Its an object. A drawing program allows a user to position standard shape which can be edited by transformations as shown in figure.

A practical program for image creation and editing might combine elements of painting and drawing, although one or the other is usually dominant. For example, a drawing program might allow the user to include a raster-type image, treating it as one shape. A painting program might let the user create "layers," which are separate images that can be layered one on top of another to create the final image. The layers can then be manipulated much like the shapes in a drawing program

Two well-known graphics programs are Adobe Photoshop and Adobe Illustrator. Adobe Photoshop is example of painting program, Adobe Illustrator is more of a drawing program.

3.2 Line drawing procedure in Computer

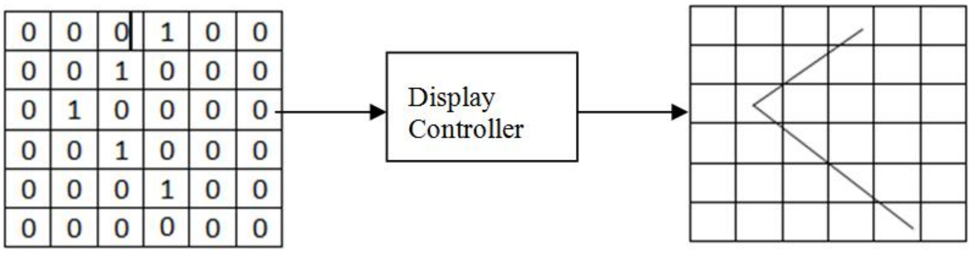
Line drawing is accomplished by calculating the intermediate point coordinates along the line path between two given end points. Since, screen pixels are referred with integer values. Plotted positions may only approximate the calculated coordinates i.e. pixels which are intensified are those which lie very close to the line path if not exactly on the line path which is in the case of perfectly horizontal, vertical or 45^0 lines only. Screen resolution is a big factor towards improving the approximation. In high resolution system the adjacent pixels are so closely spaced that the approximated line-pixels lie very close to the actual line path and hence, the plotted lines appear to be much. In a low resolution system, the same approximation technique causes lines to be displayed with a stair-step appearance.

In raster scan display device the picture information is stored in the frame buffer, the concept of frame buffer conveys that the information for the image to be projected on the screen is stored in the form of 0s and 1s making respective pixels activate and deactivate on the screen.

There are different algorithm responsible for actual display of geometries like line circle etc., on display devices, such that there is a decrease in discreteness and hence more realistic finished image is the outcome. For this one has to first scan convert the objects. This is the operation of finding out the location of pixels to be intensified and then setting the values of corresponding bits, to the desired intensity level. Each pixel on the display surface has a finite size depending on the screen resolution. Here we will consider one of the simplest line drawing algorithm to understand the concept of line formation in computer screen.

3.3 Digital Differential Analyzer Algorithm(DDA)

Frame buffer is a memory space where the information about the image to be projected on the screen is stored in and a*b matrix, in the form of 0s and 1s ; the 1s stored in an a*b matrix position s are brightened on the screen and 0s are not brightened. This information of 0s and 1s gives the required pattern on the output screen i.e for display of information as shown in fig



0	0	0	1	0	0
0	0	1	0	0	0
0	1	0	0	0	0
0	0	1	0	0	0
0	0	0	1	0	0
0	0	0	0	0	0

Picture information in frame

Output line

As the slope of the line is a crucial factor in its construction, let us consider the algorithm in two cases depending on the slope of the line whether it is >1 or <1

Case 1: m<1 : increment the x coordinate value for every unit time to approximate the pixel value of y direction

Case 2: m>1 : increment the y coordinate value for every unit time to approximate the pixel value of x direction

Derivations for both cases :

As we know the equation of line is $y=mx+c$

for $x=x_i$ we have $y_i=mx_i+c$

similarly

for $x=x_{i+1}$ we have $y_{i+1}=mx_{i+1}+c$

For case 1 : 0<=m<=1

Since x is incremented by 1 unit each time

$x_{i+1} = x_i+1$--(a)

By using equation of line $y=mx+c$ we have

$y_{i+1} = m(x_i+1)+c$, this can be written as

$mx_i+c +m$

let constant c=1, from (a) substitute $x_{i+1} =x_i+1$, final equation becomes

y_i+m--(b)

The detailed algorithm goes like this :

```
step 1:   input the initial and final point to draw the line
say initial point (x0,y0) and final point (x1, y1)
step 2:   find the slope of the line m=Δy/Δx=(y1-y0)/(x1-x0)
step 3:   while(x0<x1)
put_pixel(x, round(y), color)
(new x_val)xi=(old x_val)xi+1
(new y_val)yi=(old y_val)yi+m
```

For case 2: m>1

Since y is incremented 1 unit each time

$$y_{i+1} = y_i+1 \text{ ---(a)}$$

above equation can be rewritten as $y_{i+1}-y_i=1$

By using equation of line y=mx+c we have

$y_{i+1}-y_i = m(x_{i+1}-x_i)$, this can be written as

$1= m(x_{i+1}-x_i)$

$$x_{i+1} = x_i + 1/m \text{---(b)}$$

The detailed algorithm goes like this :

```
step 1:   input the initial and final point to draw the line
say initial point (x0,y0) and final point (x1, y1)
step 2:   find the slope of the line m=Δy/Δx=(y1-y0)/(x1-x0)
step 3:   while(y0<y1)
put_pixel(round(x),y, color)
(new x_val)xi=(old x_val)xi+1/m
(new y_val)yi=(old y_val)yi+1
```

Example :

Calculate the points between the starting point (5, 6) and ending point (8, 12).

Given-

Starting coordinates = (X_0, Y_0) = (0,0)

Ending coordinates = (X_n, Y_n) = (8, 4)

Step-01:

Calculate ΔX, ΔY and M from the given input.

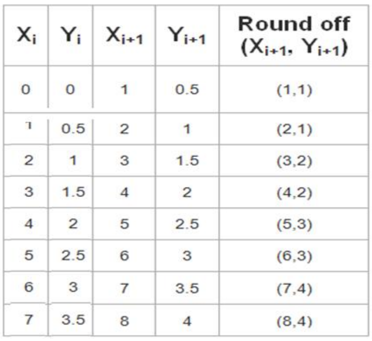
$\Delta X = X_n – X_0 = 8 – 0 = 8$

$\Delta Y = Y_n – Y_0 = 4 – 0 = 4$

$M = \Delta Y / \Delta X = 4 / 8 = 0.5$

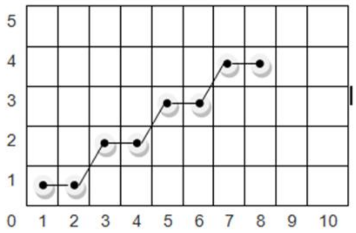
As M < 1, so case-1 is satisfied.

Now, calculate updated values for x and y until to attain the final point(8,4) .



X_i	Y_i	X_{i+1}	Y_{i+1}	Round off (X_{i+1}, Y_{i+1})
0	0	1	0.5	(1,1)
1	0.5	2	1	(2,1)
2	1	3	1.5	(3,2)
3	1.5	4	2	(4,2)
4	2	5	2.5	(5,3)
5	2.5	6	3	(6,3)
6	3	7	3.5	(7,4)
7	3.5	8	4	(8,4)

calculation of pixels using algorithm



line formation in screen with pixel marks

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IV. TRANSFORMATIONS

Transformation is nothing but changing the object with respect to size, shape, space etc., the objects are referenced by their coordinates. Changes are accomplished with geometric transformations that allow us to calculate the new coordinates. The basic geometric transformations are translation, rotation scaling and shearing. We will apply translation and rotation transformations to manipulate these geometric 2-D objects on the screen. scaling transformation are used to modify their shapes either by magnifying or reducing their sizes. We can also find similar but new shapes by taking mirror reflection and shearing,

4.1 Translation

Translation is the process of changing the position of an object. Let an object position represented with a point P(x,y) and can be moved to new position P'(x',y')with the translation factor in x and y directions such that

P'=P+V

Where P' final position, P initial position and v translation vector

$$Tv = \left\{ \begin{array}{l} x'=x+t_x \\ y'=y+t_y \end{array} \right.$$

t_x, t_y ate time taken to move along x and y axes respectively

Translation transformation cannot be represented in (2x2) matrix form. But by using Homogeneous coordinate system, we can represent translation transformation in (3x3) matrix form. This can be done by adding one more coordinate value H (x,y) coordinate point, here the value of H is always 1 for simplicity.

Thus for translation transformation , at any point(x,y)=(x+t_x, t+t_y)in 2-D Euclidian system using HCS, this translation transformation can be represented as (x,y,1)=(x+t_x, y+t_y,1). Now, we are able to represent this translation transformation in matrix form as

$$(x',y',1) = (x,y,1) . \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ t_x & t_y & 1 \end{bmatrix}$$

Introducing matrix form of translation is that it simplified the operations on composite transformation i.e., concatenating multiple transformations in case of composite transformation.

Example :

translate an object ABC with the coordinates A(0,0), B(5,0), C(5,5) by 2 units in x direction and 3 units in y direction

Soln: we can represent the given object in matrix form, using homogeneous coordinates of vertices as:

$$\begin{array}{c} A \\ B \\ C \end{array} \begin{bmatrix} X1 & Y1 & 1 \\ X2 & Y2 & 1 \\ X3 & Y3 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ 5 & 0 & 1 \\ 5 & 5 & 1 \end{bmatrix}$$

the translation factors are tx=2, ty=3

thus the transformation matrix for translation

$$Tv = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ Tx & Ty & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 2 & 3 & 1 \end{bmatrix}$$

New object point coordinates are:

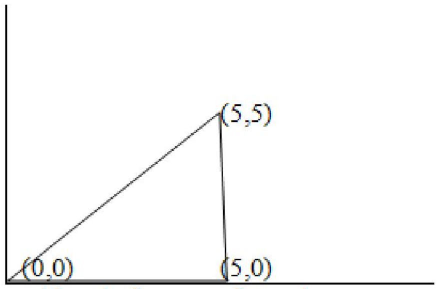
[A'B'C']=[ABC].Tv

Thus the final coordinate points are A(2,3), B(7,3) and C(7,8)

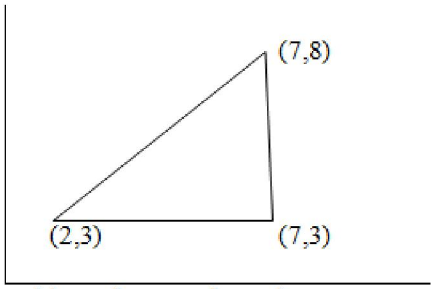
$$\begin{array}{c} A \\ B \\ C \end{array} \begin{bmatrix} X1 & Y1 & 1 \\ X2 & Y2 & 1 \\ X3 & Y3 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ 5 & 0 & 1 \\ 5 & 5 & 1 \end{bmatrix} X \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 2 & 3 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 & 3 & 1 \\ 7 & 3 & 1 \\ 7 & 8 & 1 \end{bmatrix}$$

The graphical representation is as shown below



Object before transformation

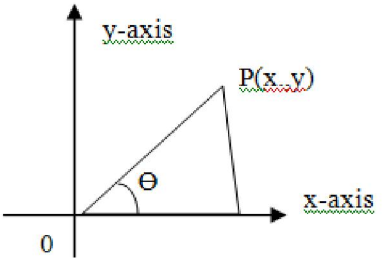


Object after transformation

4.2 Rotation

In 2-D rotation, an object is rotated by an angle Θ with respect to the origin. This angle is assumed to be positive for anticlockwise rotation. There are two cases for 2-D rotation, case 1-rotation about the origin and case 2 – rotation about an arbitrary point .

A frequently used non-Cartesian system is polar coordinate system. In polar coordinate system a coordinate position is specified by r and Θ , where r is a radial distance from the coordinate origin and Θ is an angular displacements from the horizontal. The following figure A shows a polar coordinate reference frame



We transform polar coordinates to Cartesian coordinate as

$x=r.\cos\Theta$

$y=r.\sin\Theta$

Case 1 : Rotation about the origin

Given a 2-D pint P(x,y), which we want to rotate, with respect to the origin O. the vector OP has a length 'r' and making a positive angle Φ with respect to x-axis.

Let P'(x',y') be the result of rotation of point P by an angle θ about the origin , which is shown in fig

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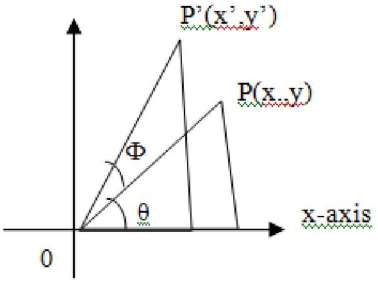

P(x,y)=P(rcos Φ, rsin Φ)
P'(x',y')=P[rcos(θ +Φ),rsin(Φ+ θ)]
The coordinates of P' are
X'=r.cos(θ +Φ)=r(cos θ cos Φ -sin θ sin Φ)
=x.cos θ -y.sin θ (where x=rcos Φ and y=rsin Φ)
Similarly
Y'=rsin(θ+ Φ)=r(sin θ cos Φ +cos θ sin Φ)
=xsin θ +ycos θ
Thus
Thus R_θ = x'=x.cos θ-ysin θ
y'=xsin θ+ysin θ

Now, the new coordinate of point P after the rotation. Matrix form of the transformation relation between P' and P is given by

$$(x'y') = (x,y)\begin{bmatrix}\cos\theta & \sin\theta \\ -\sin\theta & \cos\theta\end{bmatrix}$$

i.e $P'=P.R_\theta$

Example :

perform a 45^0 rotation of a triangle A(0,0), B(1,1),C(5,2) about the origin.

Soln : we can represent the given triangle, in matrix form, using homogeneous coordinates fo the vertices:

$$[ABC]=\begin{bmatrix}A & 0 & 0 \\ B & 1 & 1 \\ C & 5 & 2\end{bmatrix}$$

$$R_\theta= \quad R_{90}=\begin{bmatrix}\mathrm{Cos}45 & \mathrm{Sin}45 \\ -\sin 45 & \mathrm{Cos}45\end{bmatrix} = \begin{bmatrix}1/\sqrt{2} & 1/\sqrt{2} \\ -1/\sqrt{2} & 1/\sqrt{2}\end{bmatrix}$$

So the new coordinates A'B'C' of the rotated triangle

$$[A'B'C']= \quad [ABC].R_{90}\begin{bmatrix}0 & 0 \\ 1 & 1 \\ 5 & 2\end{bmatrix}\begin{bmatrix}1/\sqrt{2} & 1/\sqrt{2} \\ -1/\sqrt{2} & 1/\sqrt{2}\end{bmatrix}\begin{bmatrix}0 & 0 \\ 0 & 2/\sqrt{2} \\ 3/\sqrt{2} & 7/\sqrt{2}\end{bmatrix}$$

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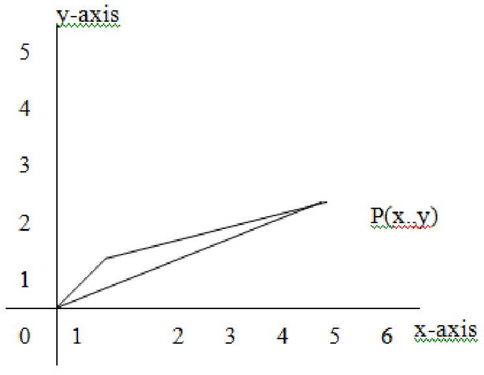
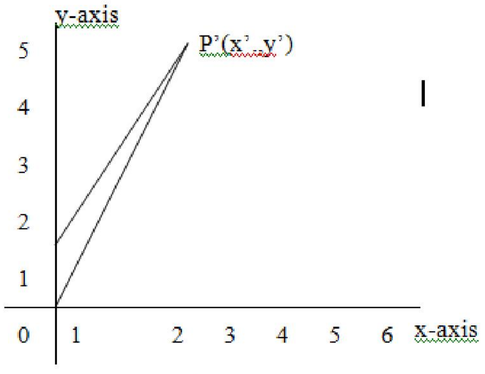


Before rotation



After rotation

4.3 Scaling

Scaling is the process of expanding or compressing the dimensions of an object.

Let P(x,y) be any pint of a given object and sx and sy be scaling factors in x and y directions respectively, then the coordinate of the scaled object can be obtained as

$x' = x.s_x$

$y' = y.s_y$

Thus the general scaling is (x,y)=(x.sx, y.sy) i.e., magnifying or compression in both x and y directions depending on scale factors sx and sy. We can represent this in 2-D matrix form as

$$(x'y') = (x,y) \begin{bmatrix} Sx & 0 \\ 0 & sy \end{bmatrix}$$

There are three cases based on positive value assigned to scale factors s_x and s_y.

Case 1 : if the values of s_x and s_y are less then 1, then the size of the object will be reduced

Case 2: : if the values of s_x and s_y are greater then 1, then the size of the object will be enlarged

Case 3: if we have same scaling factore i.e $s_x=s_y=s$ then there're will be uniform scaling in both x and y directions

Example :

Find the new coordinates of a triangle A(0,0), B(2,2), C(4,0) after it has been magnified to twice its size and reduces to half its size.

Given triangle is represented in 2-D matrix as follows

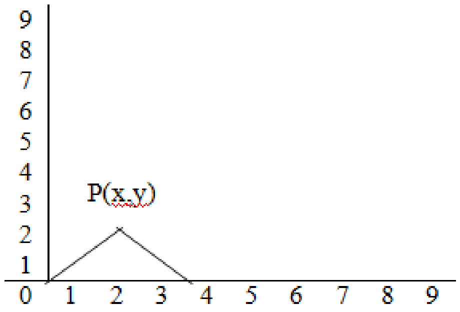
$$\begin{array}{c} A \\ B \\ C \end{array} \begin{bmatrix} 0 & 0 \\ 2 & 2 \\ 4 & 0 \end{bmatrix}$$

Choosing s=2, the matrix of scaling is

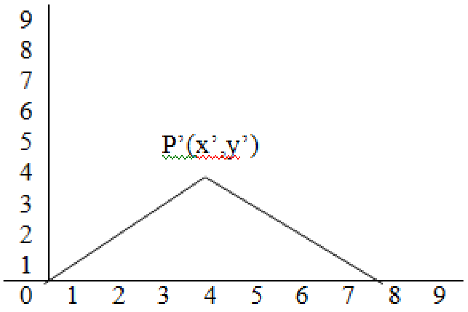
$$S_{sx,sy} = \quad S_{2,2} = \begin{array}{c} A \\ B \end{array} \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$$

So the new coordination A'B'C' of the scaled triangle ABC can be found as

$$[A'B'C'] = [ABC].R_{22} \begin{bmatrix} 0 & 0 \\ 2 & 2 \\ 4 & 0 \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} 0 & 0 \\ 4 & 4 \\ 8 & 0 \end{bmatrix}$$



Before scaling



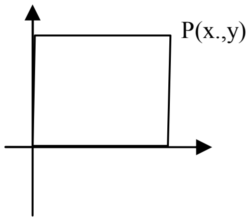
After scaling

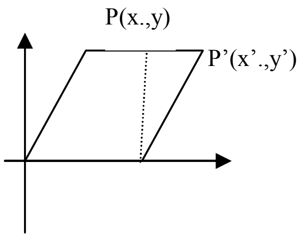
4.4 Shearing

Shearing transformations are used for modifying the shapes of 2-D and 3-D objects. The effect of a shear transformation looks like pushing a geometric object in a direction that is parallel to a coordinate plane or a coordinate axis. How far a direction is pashed is determined by its shearing factor

x-shear about the origin

let an object pint P(x,y) be moved to P'(x',y') in the x-direction, by the given scale parameter 'a' about the origin.





Thus the points P(x,y) and P'(x',y') have the following relationship

$$x' = x + a_y$$
$$y' = y$$

Where a is constant (shearing factor) that measured the degree of shearing. If a is negative then the shearing is in opposite direction.

The matrix form is as follows

$$(x',y') = (x,y) \begin{bmatrix} 1 & 0 \\ a & 1 \end{bmatrix}$$

i.e $P_h' = P_h Sh_x(a)$

where P_h and P_h' represents object points , before and after required transformations

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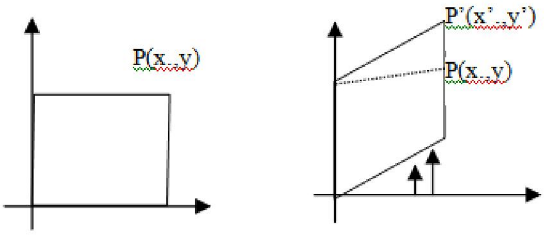
y-shear about the origin :

let an object pint P(x,y) be moved to P'(x',y') in the y-direction, by the given scale parameter 'b' about the origin.



Thus the points P(x,y) and P'(x',y') have the following relationship

x'=x

$y'=y+b_x$

Where b is constant (shearing factor) that measured the degree of shearing. If b is negative then the shearing is in opposite direction.

The matrix form is as follows

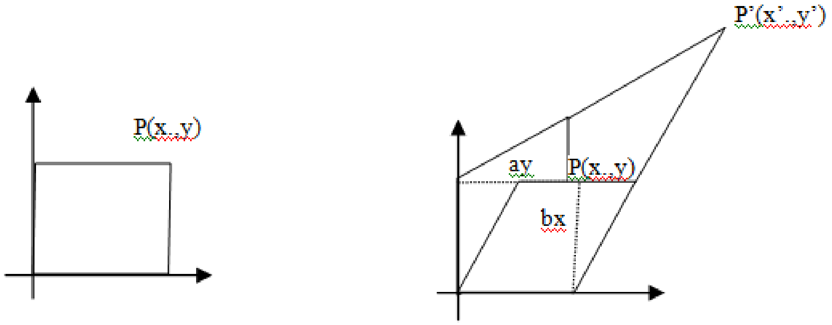
$$(x',y')= \quad (x,y)\begin{bmatrix} 1 & b \\ 0 & 1 \end{bmatrix}$$

i.e $P_h'=P_hSh_y(a)$

where Ph and Ph' represents object points , before and after required transformation.es

xy-shear about the origin :

let an object pint P(x,y) be moved to P'(x',y') as aresult of shear transformation in both x-direction and y-direction, with the shearing factors a and b respectively about the origin.



Before shearing After shearing

Thus the points P(x,y) and P'(x',y') have the following relationship

$x'=x+a_y$

$y'=y+b_x$

Where a_y and b_x are shear factors in x and y directions, respectively that measured the degree of shearing.

The matrix form is as follows

$$(x',y')= \quad (x,y)\begin{bmatrix} 1 & b \\ a & 1 \end{bmatrix}$$

i.e $P_h' = P_h Sh_y(a,b)$
where Ph and Ph' represents object points , before and after required transformation.es

V. LITERATURE REVIEW

Title:" Factual to Virtual Visualization ";

Introduction: The field of computer graphics has witnessed significant advancements in real-time rendering techniques over the past decade. Understanding the working concept of computer graphics is a challenging task as it is a very wide concept. Main objective of this paper is to explore the comprehensive overview of the internal working concept of computer system to map real world image to computer screen, highlighting the different components, working concept and their applications. It is the part of Computer Graphics, for this there may be huge quantity of resources available. But, it is difficult to integrate useful concepts to get the required objective i.e., how real image is displayed in computer screen. The paper explained the concept in much simple form, so that all beginners and nonprogrammers also can understand it very easily from minimum content. This paper is encapsulation of my subject knowledge in the journey of thirteen years teaching experience and some of resources available as mentioned in bibliography.

VI. RESULTS AND DISCUSSION

The paper illustrate the role of display devices to generate and output image
Different image properties and their meaning with example
What is the image quality, how it is exhibited with respect to pixels
Formation of images using raster scan(pixel wise formation of an image) and random scan(image formation by line drawing commands) display techniques
Difference between painting pictures and drawing objects
Drawing process, selection of pixels, illustrated with DDA line drawing algorithm. Different cases of algorithm are proved mathematically, written algorithm based on output and are implemented in the system.
Transformation of image to change its original appearance, four important transformations are derived with mathematical concepts and are implemented to system

VII. CONCLUSION

In conclusion, this literature review highlights transformation of the real world objects into an digital or virtual images. It identifies the key research areas and challenges that have been addressed so far and points out the directions for future research. The paper has enabled an canalization of more realistic and interactive visual experiences, with ongoing efforts focused on enhancing the fidelity, efficiency, and scalability of real facts to virtual systems.

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