Computer Graphics & Types

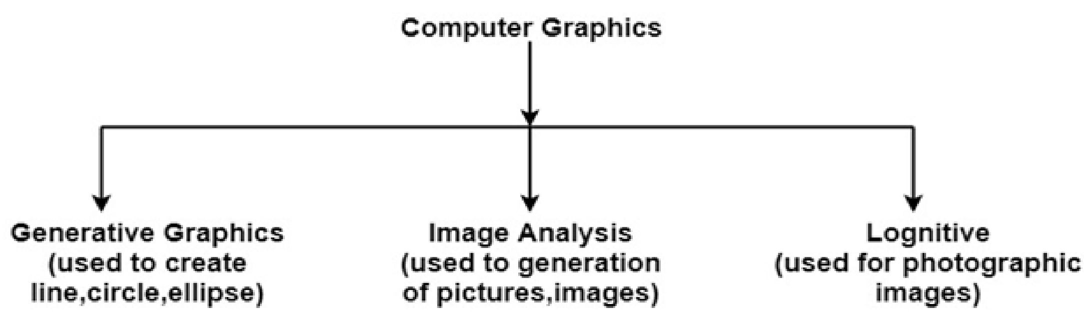
Definition of Computer Graphics:

It is the use of computers to create and manipulate pictures on a display device. It comprises of software techniques to create, store, modify, represents pictures.

Why computer graphics used?

Suppose a shoe manufacturing company want to show the sale of shoes for five years. For this vast amount of information is to store. So a lot of time and memory will be needed. This method will be tough to understand by a common man. In this situation graphics is a better alternative. Graphics tools are charts and graphs. Using graphs, data can be represented in pictorial form. A picture can be understood easily just with a single look.

Interactive computer graphics work using the concept of two-way communication between computer users. The computer will receive signals from the input device, and the picture is modified accordingly. Picture will be changed quickly when we apply command.



Applications of Computer Graphics

Application of Computer Graphics

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1. Education and Training: Computer-generated model of the physical, financial and economic system is often used as educational aids. Model of physical systems, physiological system, population trends or equipment can help trainees to understand the operation of the system.

For some training applications, particular systems are designed. For example Flight Simulator.

Flight Simulator: It helps in giving training to the pilots of airplanes. These pilots spend much of their training not in a real aircraft but on the ground at the controls of a Flight Simulator.

Advantages:

1. Fuel Saving
2. Safety
3. Ability to familiarize the training with a large number of the world's airports.

2. Use in Biology: Molecular biologist can display a picture of molecules and gain insight into their structure with the help of computer graphics.

3. Computer-Generated Maps: Town planners and transportation engineers can use computer-generated maps which display data useful to them in their planning work.

4. Architect: Architect can explore an alternative solution to design problems at an interactive graphics terminal. In this way, they can test many more solutions that would not be possible without the computer.

5. Presentation Graphics: Example of presentation Graphics are bar charts, line graphs, pie charts and other displays showing relationships between multiple parameters. Presentation Graphics is commonly used to summarize

- Financial Reports
- Statistical Reports
- Mathematical Reports
- Scientific Reports
- Economic Data for research reports
- Managerial Reports
- Consumer Information Bulletins
- And other types of reports

6. Computer Art: Computer Graphics are also used in the field of commercial arts. It is used to generate television and advertising commercial.

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7. Entertainment: Computer Graphics are now commonly used in making motion pictures, music videos and television shows.

8. Visualization: It is used for visualization of scientists, engineers, medical personnel, business analysts for the study of a large amount of information.

9. Educational Software: Computer Graphics is used in the development of educational software for making computer-aided instruction.

10. Printing Technology: Computer Graphics is used for printing technology and textile design.

Display Processors

Display Processor:

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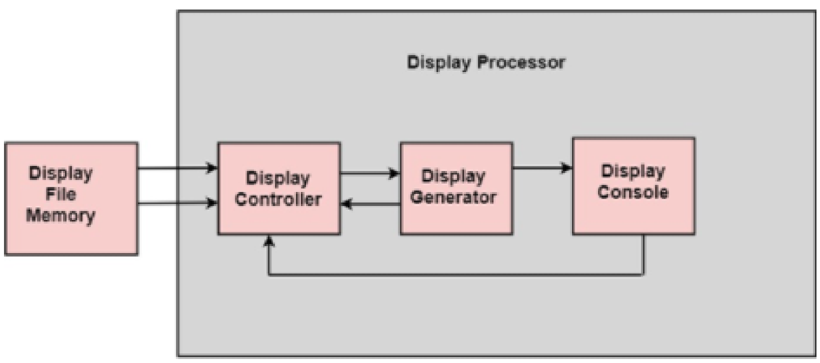
It is interpreter or piece of hardware that converts display processor code into pictures. It is one of the four main parts of the display processor

Parts of Display Processor

1. Display File Memory
2. Display Processor
3. Display Generator
4. Display Console



Block diagram of Display System

Display File Memory: It is used for generation of the picture. It is used for identification of graphic entities.

Display Controller:

1. It handles interrupt
2. It maintains timings
3. It is used for interpretation of instruction.

Display Generator:

1. It is used for the generation of character.
2. It is used for the generation of curves.

Display Console: It contains CRT, Light Pen, and Keyboard and deflection system.

The raster scan system is a combination of some processing units. It consists of the control processing unit (CPU) and a particular processor called a display controller. Display Controller controls the operation of the display device. It is also called a video controller.

Working: The video controller in the output circuitry generates the horizontal and vertical drive signals so that the monitor can sweep. Its beam across the screen during raster scans.

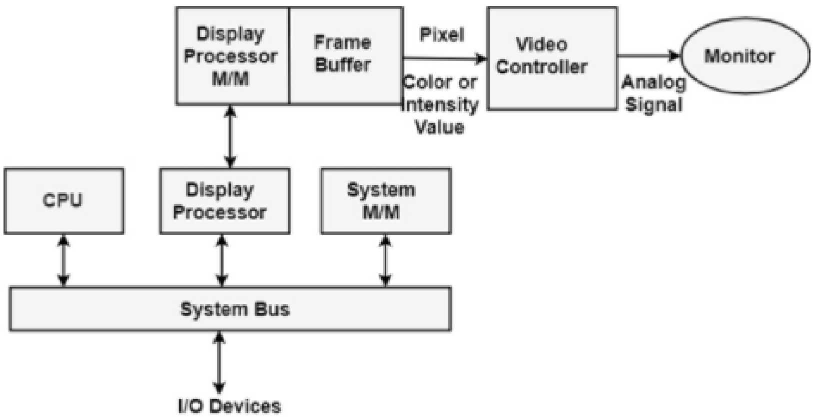


Fig: Architecture of a Raster Display System with a Display Processor

As fig showing that 2 registers (X register and Y register) are used to store the coordinate of the screen pixels. Assume that y values of the adjacent scan lines increased by 1 in an upward direction starting from 0 at the bottom of the screen to y_{max} at the top and along each scan line the screen pixel positions or x values are incremented by 1 from 0 at the leftmost position to x_{max} at the rightmost position.

The origin is at the lowest left corner of the screen as in a standard Cartesian coordinate system.

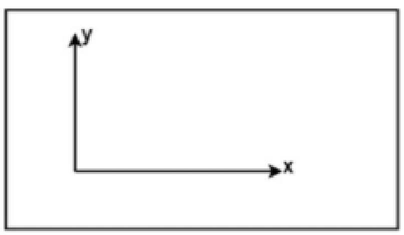


Fig: The origin of the coordinate system for identifying screen positions is usually specified in the lower-left corner.

At the start of a **Refresh Cycle**:

X register is set to 0 and y register is set to y_{max}. This (x, y') address is translated into a memory address of frame buffer where the color value for this pixel position is stored.

The controller receives this color value (a binary no) from the frame buffer, breaks it up into three parts and sends each element to a separate Digital-to-Analog Converter (DAC).

These voltages, in turn, controls the intensity of 3 e-beam that are focused at the (x, y) screen position by the horizontal and vertical drive signals.

This process is repeated for each pixel along the top scan line, each time incrementing the X register by Y.

As pixels on the first scan line are generated, the X register is incremented through x_{max}.

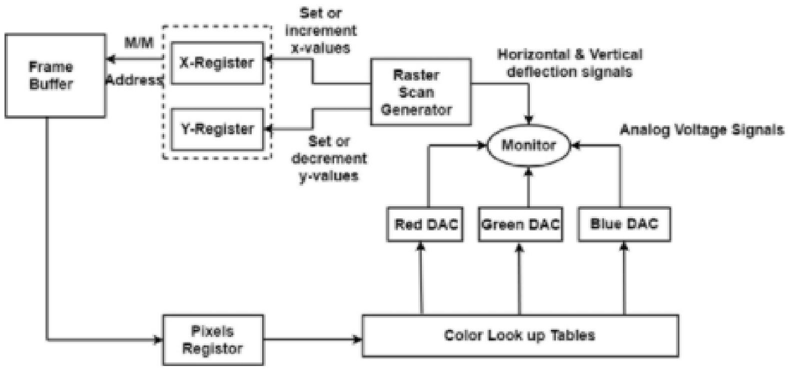
Then x register is reset to 0, and y register is decremented by 1 to access the next scan line.

Pixel along each scan line is then processed, and the procedure is repeated for each successive scan line units pixels on the last scan line (y=0) are generated.

For a display system employing a color look-up table frame buffer value is not directly used to control the CRT beam intensity.

It is used as an index to find the three pixel-color value from the look-up table. This lookup operation is done for each pixel on every display cycle.

As the time available to display or refresh a single pixel in the screen is too less, accessing the frame buffer every time for reading each pixel intensity value would consume more time what is allowed:



Multiple adjacent pixel values are fetched to the frame buffer in single access and stored in the register.

After every allowable time gap, the one-pixel value is shifted out from the register to control the warm intensity for that pixel.

The procedure is repeated with the next block of pixels,and so on, thus the whole group of pixels will be processed.

Display Devices:

The most commonly used display device is a video monitor. The operation of most video monitors based on CRT (Cathode Ray Tube). The following display devices are used:

1. Refresh Cathode Ray Tube
2. Random Scan and Raster Scan
3. Color CRT Monitors
4. Direct View Storage Tubes
5. Flat Panel Display
6. Lookup Table

Random/Vector vs Raster Display

Random Scan and Raster Scan Display:

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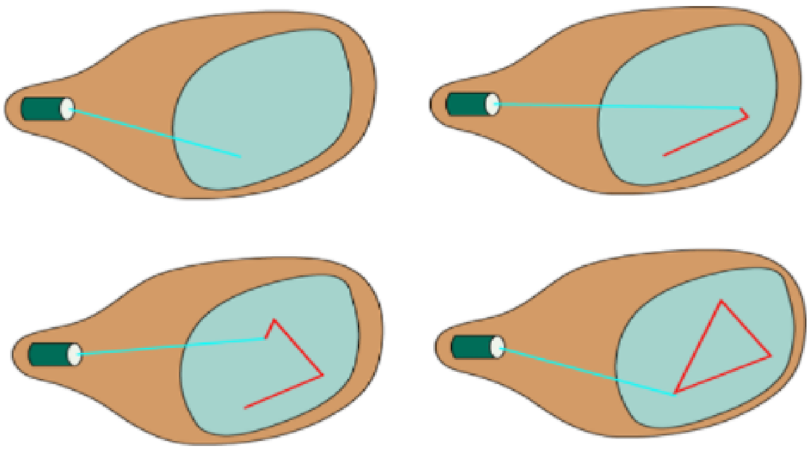
Random Scan Display:

Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen. The picture is constructed out of a sequence of straight-line segments. Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its x & y coordinates define each point. After drawing the picture. The system cycles back to the first line and design all the lines of the image 30 to 60 time each second. The process is shown in fig:



Random-scan monitors are also known as vector displays or stroke-writing displays or calligraphic displays.

Advantages:

1. A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
2. Produce smooth line drawings.
3. High Resolution

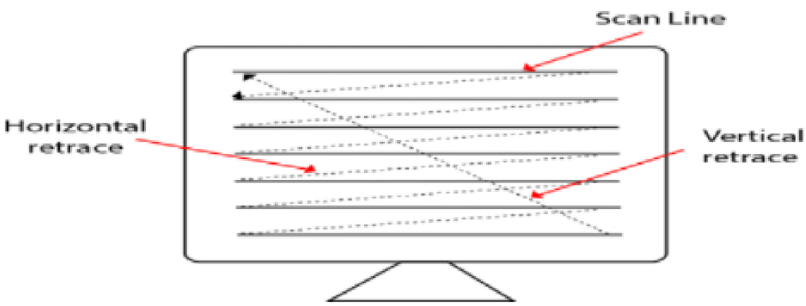
Disadvantages:

1. Random-Scan monitors cannot display realistic shades scenes.

Raster Scan Display:

A Raster Scan Display is based on intensity control of pixels in the form of a rectangular box called Raster on the screen. Information of on and off pixels is stored in refresh buffer or Frame buffer. Televisions in our house are based on Raster Scan Method. The raster scan system can store information of each pixel position, so it is suitable for realistic display of objects. Raster Scan provides a refresh rate of 60 to 80 frames per second.

Frame Buffer is also known as Raster or bit map. In Frame Buffer the positions are called picture elements or pixels. Beam refreshing is of two types. First is horizontal retracing and second is vertical retracing. When the beam starts from the top left corner and reaches the bottom right scale, it will again return to the top left side called at vertical retrace. Then it will again more horizontally from top to bottom call as horizontal retracing shown in fig:



Types of Scanning or travelling of beam in Raster Scan

1. Interlaced Scanning
2. Non-Interlaced Scanning

In Interlaced scanning, each horizontal line of the screen is traced from top to bottom. Due to which fading of display of object may occur. This problem can be solved by Non-Interlaced scanning. In this first of all odd numbered lines are traced or visited by an electron beam, then in the next circle, even number of lines are located.

For non-interlaced display refresh rate of 30 frames per second used. But it gives flickers. For interlaced display refresh rate of 60 frames per second is used.

Advantages:

1. Realistic image
2. Million Different colors to be generated
3. Shadow Scenes are possible.

Disadvantages:

1. Low Resolution
2. Expensive

Differentiate between Random and Raster Scan Display:

Random Scan	Raster Scan
1. It has high Resolution	1. Its resolution is low.
2. It is more expensive	2. It is less expensive
3. Any modification if needed is easy	3.Modification is tough
4. Solid pattern is tough to fill	4.Solid pattern is easy to fill
5. Refresh rate depends or resolution	5. Refresh rate does not depend on the picture.
6. Only screen with view on an area is displayed.	6. Whole screen is scanned.
7. Beam Penetration technology come under it.	7. Shadow mark technology came under this.
8. It does not use interlacing method.	8. It uses interlacing
9. It is restricted to line drawing applications	9. It is suitable for realistic display.

CRT Display

Color CRT Monitors:

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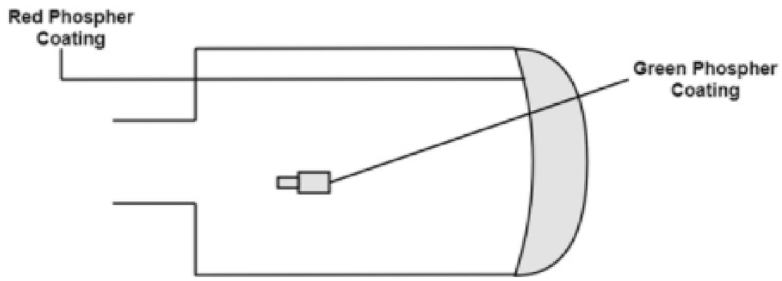
The CRT Monitor display by using a combination of phosphors. The phosphors are different colors. There are two popular approaches for producing color displays with a CRT are:

1. Beam Penetration Method
2. Shadow-Mask Method

1. Beam Penetration Method:

The Beam-Penetration method has been used with random-scan monitors. In this method, the CRT screen is coated with two layers of phosphor, red and green and the displayed color depends on how far the electron beam penetrates the phosphor layers. This method produces four colors only, red, green, orange and yellow. A beam of slow electrons excites the outer red layer only; hence screen shows red color only. A beam of high-speed electrons excites the inner green layer. Thus screen shows a green color.



Advantages:

1. Inexpensive

Disadvantages:

1. Only four colors are possible
2. Quality of pictures is not as good as with another method.

2. Shadow-Mask Method:

- Shadow Mask Method is commonly used in Raster-Scan System because they produce a much wider range of colors than the beam-penetration method.
- It is used in the majority of color TV sets and monitors.

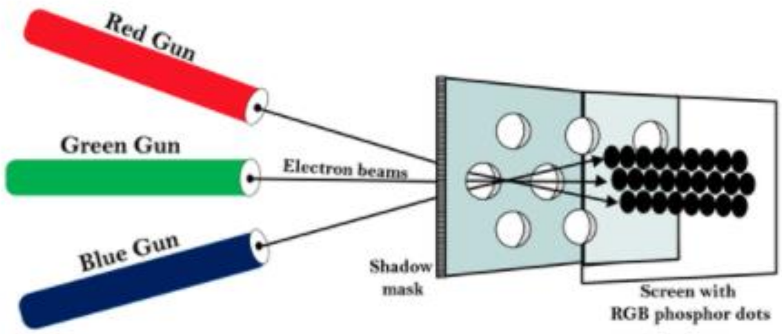
Construction: A shadow mask CRT has 3 phosphor color dots at each pixel position.

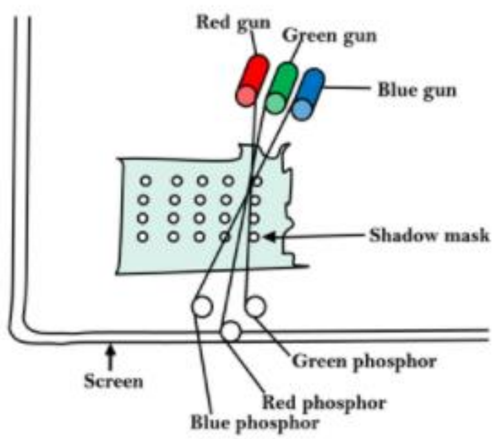
- One phosphor dot emits: red light
- Another emits: green light
- Third emits: blue light

This type of CRT has 3 electron guns, one for each color dot and a shadow mask grid just behind the phosphor coated screen.

Shadow mask grid is pierced with small round holes in a triangular pattern.

Figure shows the delta-delta shadow mask method commonly used in color CRT system.





The Shadow mask CRT

Working: Triad arrangement of red, green, and blue guns.

The deflection system of the CRT operates on all 3 electron beams simultaneously; the 3 electron beams are deflected and focused as a group onto the shadow mask, which contains a sequence of holes aligned with the phosphor- dot patterns.

When the three beams pass through a hole in the shadow mask, they activate a dotted triangle, which occurs as a small color spot on the screen.

The phosphor dots in the triangles are organized so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.

Inline arrangement: Another configuration for the 3 electron guns is an Inline arrangement in which the 3

electron guns and the corresponding red-green-blue color dots on the screen, are aligned along one scan line rather of in a triangular pattern.

This inline arrangement of electron guns in easier to keep in alignment and is commonly used in high-resolution color CRT's.

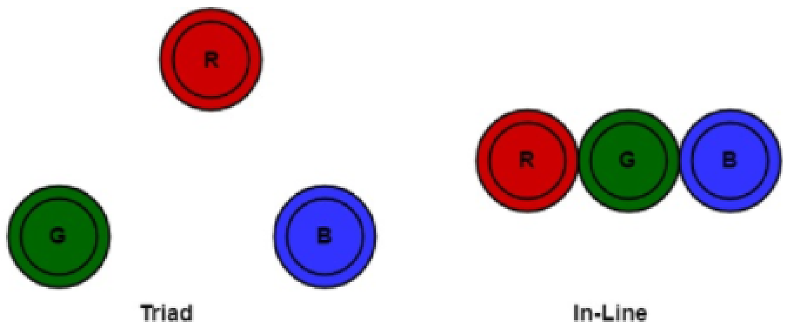


Fig: Triad-and -in-line arrangements of red, green and blue electron guns of CRT for color monitors.

Advantage:

1. Realistic image
2. Million different colors to be generated
3. Shadow scenes are possible

Disadvantage:

1. Relatively expensive compared with the monochrome CRT.
2. Relatively poor resolution
3. Convergence Problem

Scan Conversion & Algorithms

Scan Conversion Definition

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It is a process of representing graphics objects a collection of pixels. The graphics objects are continuous. The pixels used are discrete. Each pixel can have either on or off state.

The circuitry of the video display device of the computer is capable of converting binary values (0, 1) into a pixel on and pixel off information. 0 is represented by pixel off. 1 is represented using pixel on. Using this ability graphics computer represent picture having discrete dots.

Any model of graphics can be reproduced with a dense matrix of dots or points. Most human beings think graphics objects as points, lines, circles, ellipses. For generating graphical object, many algorithms have been developed.

Advantage of developing algorithms for scan conversion

1. Algorithms can generate graphics objects at a faster rate.
2. Using algorithms memory can be used efficiently.
3. Algorithms can develop a higher level of graphical objects.

Examples of objects which can be scan converted

1. Point
2. Line
3. Sector
4. Arc
5. Ellipse
6. Rectangle
7. Polygon
8. Characters
9. Filled Regions

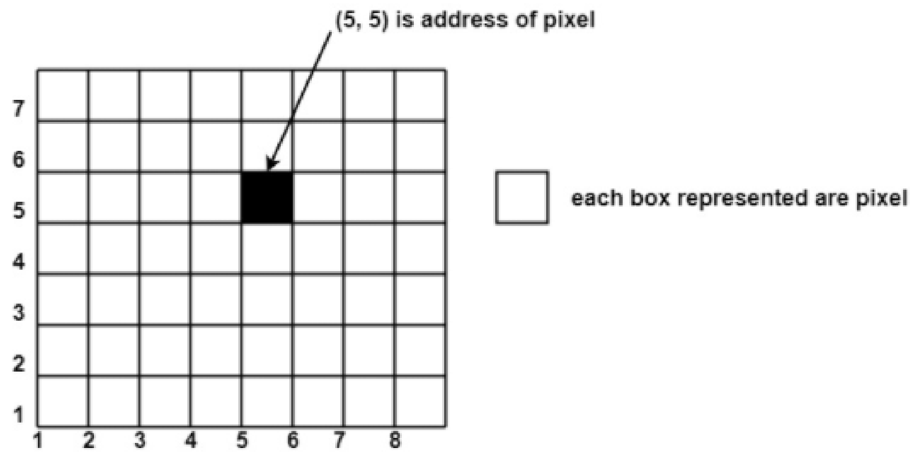
The process of converting is also called as rasterization. The algorithms implementation varies from one computer system to another computer system. Some algorithms are implemented using the software. Some are performed using hardware or firmware. Some are performed using various combinations of hardware, firmware, and software.

Pixel or Pel:

The term pixel is a short form of the picture element. It is also called a point or dot. It is the smallest picture unit accepted by display devices. A picture is constructed from hundreds of such pixels. Pixels are generated using commands. Lines, circle, arcs, characters; curves are drawn with closely spaced pixels. To display the digit or letter matrix of pixels is used.

The closer the dots or pixels are, the better will be the quality of picture. Closer the dots are, crisper will be the picture. Picture will not appear jagged and unclear if pixels are closely spaced. So the quality of the picture is directly proportional to the density of pixels on the screen.

Pixels are also defined as the smallest addressable unit or element of the screen. Each pixel can be assigned an address as shown in fig:



Different graphics objects can be generated by setting the different intensity of pixels and different colors of pixels. Each pixel has some co-ordinate value. The coordinate is represented using row and column.

P (5, 5) used to represent a pixel in the 5th row and the 5th column. Each pixel has some intensity value which is represented in memory of computer called a **frame buffer**. Frame Buffer is also called a refresh buffer. This memory is a storage area for storing pixels values using which pictures are displayed. It is also called as digital memory. Inside the buffer, image is stored as a pattern of binary digits either 0 or 1. So there is an array of 0 or 1 used to represent the picture. In black and white monitors, black pixels are represented using 1's and white pixels are represented using 0's. In case of systems having one bit per pixel frame buffer is called a bitmap. In systems with multiple bits per pixel it is called a pixmap.

Circle Conversion

Defining a Circle:

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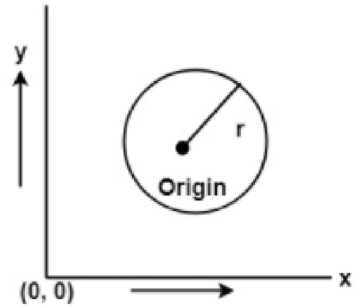
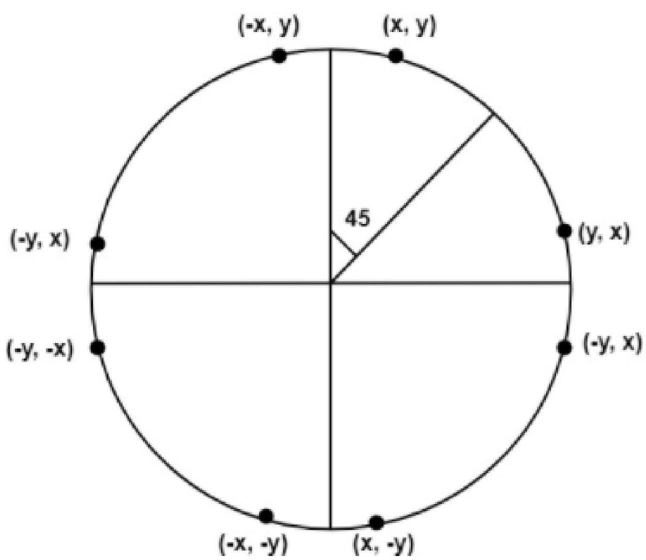
Circle is an eight-way symmetric figure. The shape of circle is the same in all quadrants. In each quadrant, there are two octants. If the calculation of the point of one octant is done, then the other seven points can be calculated easily by using the concept of eight-way symmetry.

For drawing, circle considers it at the origin. If a point is $P_1(x, y)$, then the other seven points will be



P2 (x, -y)
P3(-x, -y)
P4 (-x, y)
P5 (y, x)
P6 (y, -x)
P7 (-y, -x)
P8 (-y, x)



So we will calculate only 45°arc. From which the whole circle can be determined easily.

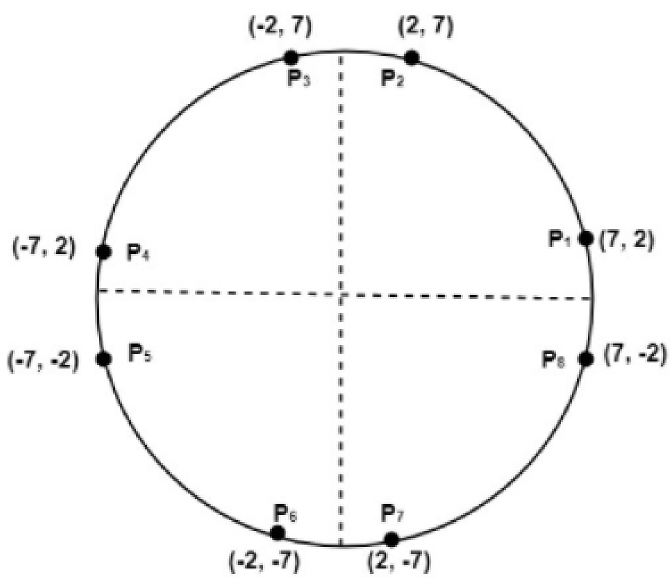
If we want to display circle on screen then the putpixel function is used for eight points as shown below:

putpixel (x, y, color)
putpixel (x, -y, color)
putpixel (-x, y, color)
putpixel (-x, -y, color)
putpixel (y, x, color)
putpixel (y, -x, color)
putpixel (-y, x, color)
putpixel (-y, -x, color)

Example: Let we determine a point (2, 7) of the circle then other points will be (2, -7), (-2, -7), (-2, 7), (7, 2), (-7, 2), (-7, -2), (7, -2)

These seven points are calculated by using the property of reflection. The reflection is accomplished in the following way:

The reflection is accomplished by reversing x, y co-ordinates.



Eight way symmetry of a Circle

There are two standards methods of mathematically defining a circle centered at the origin.

1. Defining a circle using Polynomial Method
2. Defining a circle using Polar Co-ordinates

Eclipse Conversion

Scan Converting a Ellipse:

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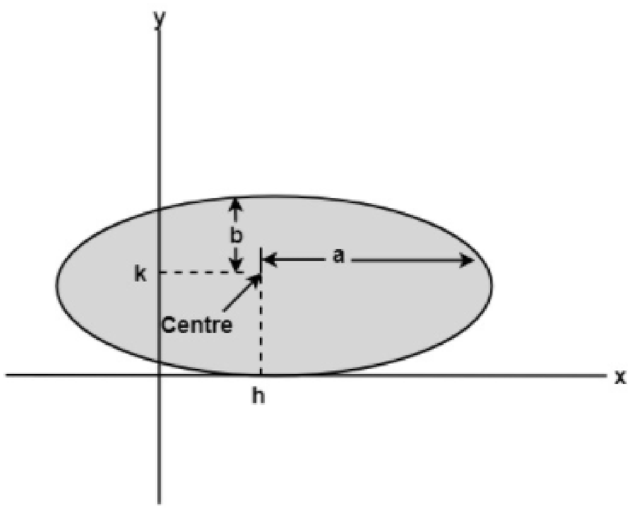
The ellipse is also a symmetric figure like a circle but is four-way symmetry rather than eight-way.



Program to Implement Ellipse Drawing Algorithm:

```
#include<stdio.h>
#include<conio.h>
#include<graphics.h>
#include<math.h>
void disp();
float x,y;
intxc,yc;
void main()
{
        intgd=DETECT,gm,a,b;
        float p1,p2;
        clrscr();
        initgraph(&gd,&gm,"c:\\turboc3\\bgi");
        printf("*** Ellipse Generating Algorithm ***\n");
```

```
        printf("Enter the value of Xc\t");
        scanf("%d",&xc);
        printf("Enter the value of yc\t");
        scanf("%d",&yc);
        printf("Enter X axis length\t");
        scanf("%d",&a);
        printf("Enter Y axis length\t");
        scanf("%d",&b);
        x=0;y=b;
        disp();
        p1=(b*b)-(a*a*b)+(a*a)/4;
        while((2.0*b*b*x)<=(2.0*a*a*y))
        {
                x++;
                if(p1<=0)
                p1=p1+(2.0*b*b*x)+(b*b);
                else
    {
                        y--;
                        p1=p1+(2.0*b*b*x)+(b*b)-(2.0*a*a*y);
     }
                disp();
                x=-x;
                disp();
                x=-x;
                delay(50);
         }
```

```
x=a;
y=0;
disp();
p2=(a*a)+2.0*(b*b*a)+(b*b)/4;
while((2.0*b*b*x)>(2.0*a*a*y))
{
        y++;
        if(p2>0)
        p2=p2+(a*a)-(2.0*a*a*y);
        else
{
                x--;
                p2=p2+(2.0*b*b*x)-(2.0*a*a*y)+(a*a);
}
        disp();
        y=-y;
        disp();
        y=-y;
        delay(50);
}
getch();
closegraph();
}
void disp()
{
        putpixel(xc+x,yc+y,7);
        putpixel(xc-x,yc+y,7);
```

```
putpixel(xc+x,yc-y,7);

putpixel(xc+x,yc-y,7);

}
```

Output:

There two methods of defining an Ellipse:

1. Polynomial Method of defining an Ellipse
2. Trigonometric method of defining an Ellipse

Transformation & Types

Introduction of Transformations

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Computer Graphics provide the facility of viewing object from different angles. The architect can study building from different angles i.e.

1. Front Evaluation
2. Side elevation
3. Top plan

A Cartographer can change the size of charts and topographical maps. So if graphics images are coded as numbers, the numbers can be stored in memory. These numbers are modified by mathematical operations called as Transformation.

The purpose of using computers for drawing is to provide facility to user to view the object from different angles, enlarging or reducing the scale or shape of object called as Transformation.

Two essential aspects of transformation are given below:

1. Each transformation is a single entity. It can be denoted by a unique name or symbol.
2. It is possible to combine two transformations, after connecting a single transformation is obtained, e.g., A is a transformation for translation. The B transformation performs scaling. The combination of two is C=AB. So C is obtained by concatenation property.

There are two complementary points of view for describing object transformation.

1. Geometric Transformation: The object itself is transformed relative to the coordinate system or background. The mathematical statement of this viewpoint is defined by geometric transformations applied to each point of the object.
2. Coordinate Transformation: The object is held stationary while the coordinate system is transformed relative to the object. This effect is attained through the application of coordinate transformations.

An example that helps to distinguish these two viewpoints:

The movement of an automobile against a scenic background we can simulate this by

- Moving the automobile while keeping the background fixed-(Geometric Transformation)
- We can keep the car fixed while moving the background scenery- (Coordinate Transformation)

Types of Transformations:

1. Translation
2. Scaling
3. Rotating
4. Reflection
5. Shearing

Translation of point:

To translate a point from coordinate position (x, y) to another (x_1 y_1), we add algebraically the translation distances T_x and T_y to original coordinate.

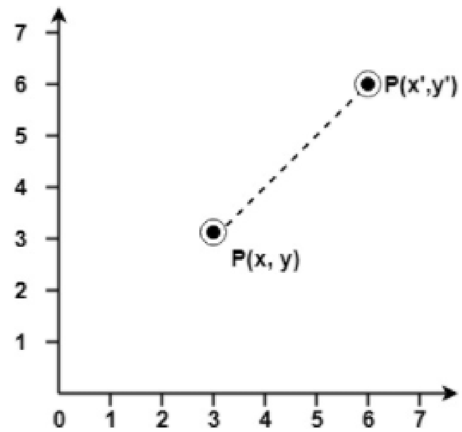
$$x_1=x+T_x$$
$$y_1=y+T_y$$

The translation pair (T_x,T_y) is called as shift vector.

Translation is a movement of objects without deformation. Every position or point is translated by the same amount. When the straight line is translated, then it will be drawn using endpoints.

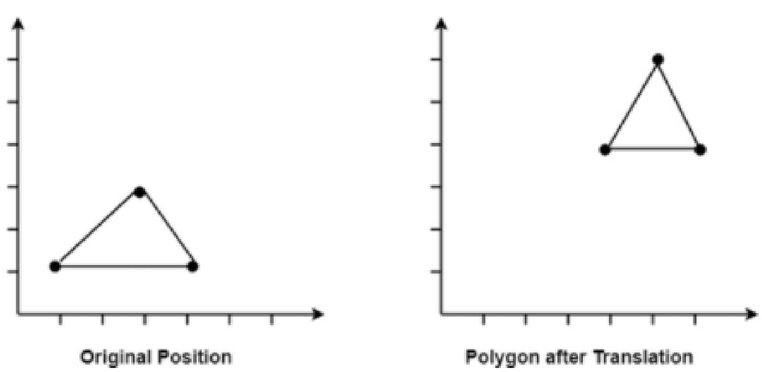
For translating polygon, each vertex of the polygon is converted to a new position. Similarly, curved objects are translated. To change the position of the circle or ellipse its center coordinates are transformed, then the object is drawn using new coordinates.

Let P is a point with coordinates (x, y). It will be translated as (x^1 y^1).



Translation

Translation of Polygon



Scaling:

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It is used to alter or change the size of objects. The change is done using scaling factors. There are two scaling factors, i.e. S_x in x direction S_y in y-direction. If the original position is x and y. Scaling factors are S_x and S_y then the value of coordinates after scaling will be x^1 and y_1.

If the picture to be enlarged to twice its original size then $S_x = S_y = 2$. If $S_x$and S_y are not equal then scaling will occur but it will elongate or distort the picture.

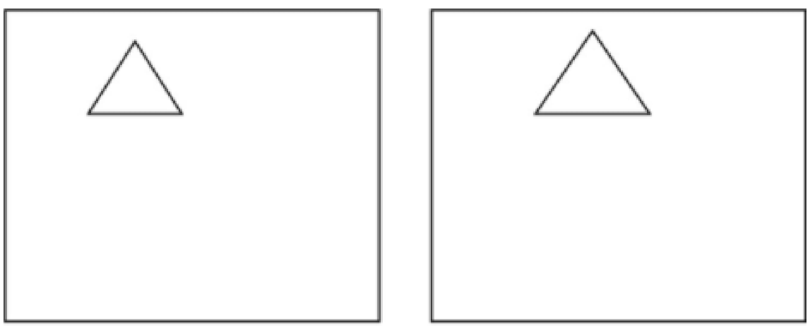
If scaling factors are less than one, then the size of the object will be reduced. If scaling factors are higher than one, then the size of the object will be enlarged.

If $S_x$and $S_y$are equal it is also called as Uniform Scaling. If not equal then called as Differential Scaling. If scaling factors with values less than one will move the object closer to coordinate origin, while a value higher than one will move coordinate position farther from origin.

Enlargement: If $T_1=\begin{bmatrix}2 & 0\\0 & 2\end{bmatrix}$,If $(x_1\ y_1)$is original position and $T_1$is translation vector then $(x_2\ y_2)$ are coordinated after scaling

$$[x_2 y_2] = [\ x_1 y_1] \begin{bmatrix}2 & 0\\0 & 2\end{bmatrix} = [2x_1 2y_1]$$

The image will be enlarged two times



Original Image Enlarged Image

Reduction: If $T_1=\begin{bmatrix}0.5 & 0\\0 & 0.5\end{bmatrix}$. If $(x_1\ y_1)$ is original position and T_1 is translation vector, then $(x_2\ y_2)$ are coordinates after scaling

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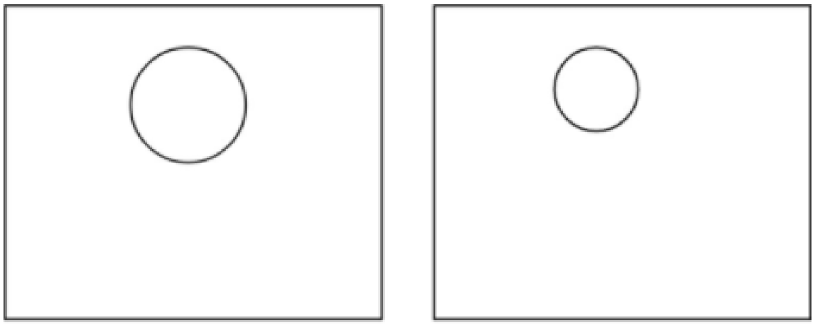
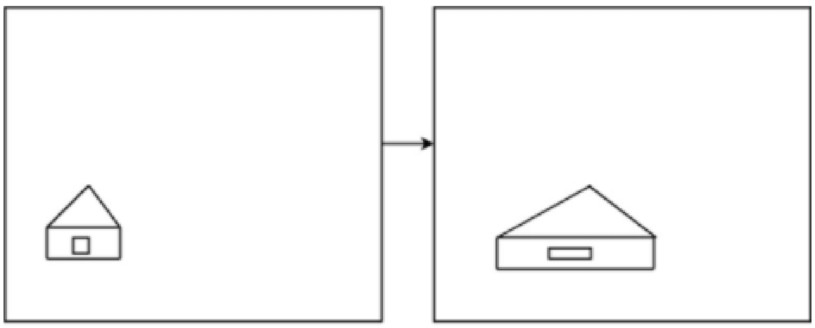
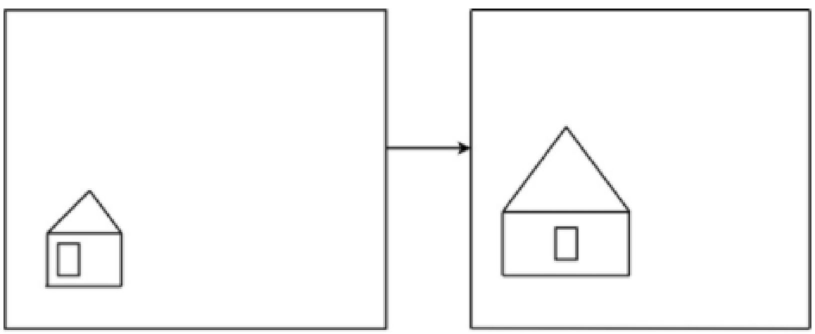
$$[x_2 y_2] = [\ x_1 y_1] \begin{bmatrix} 0.5 & 0 \\ 0 & 0.5 \end{bmatrix} = [.5x_1 . 5y_1]$$



Original Image **Reduction Image**



Original Object **Object after scaling in X direction**



Original Object **Object after scaling in Y direction**

Matrix for Scaling:

$$S = \begin{vmatrix} Sx & 0 & 0 \\ 0 & Sy & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

Rotation:

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It is a process of changing the angle of the object. Rotation can be clockwise or anticlockwise. For rotation, we have to specify the angle of rotation and rotation point. Rotation point is also called a pivot point. It is print about which object is rotated.

Types of Rotation:

1. Anticlockwise
2. Counterclockwise

The positive value of the pivot point (rotation angle) rotates an object in a counter-clockwise (anti-clockwise) direction.

The negative value of the pivot point (rotation angle) rotates an object in a clockwise direction.

When the object is rotated, then every point of the object is rotated by the same angle.

Straight Line: Straight Line is rotated by the endpoints with the same angle and redrawing the line between new endpoints.

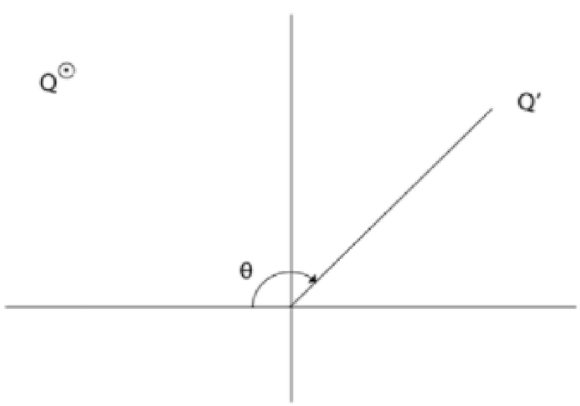
Polygon: Polygon is rotated by shifting every vertex using the same rotational angle.

Curved Lines: Curved Lines are rotated by repositioning of all points and drawing of the curve at new positions.

Circle: It can be obtained by center position by the specified angle.

Ellipse: Its rotation can be obtained by rotating major and minor axis of an ellipse by the desired angle.

Rotation in anticlockwise direction



Q is original position
Q ' is final rotated position

Reflection:

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It is a transformation which produces a mirror image of an object. The mirror image can be either about x-axis or y-axis. The object is rotated by180°.

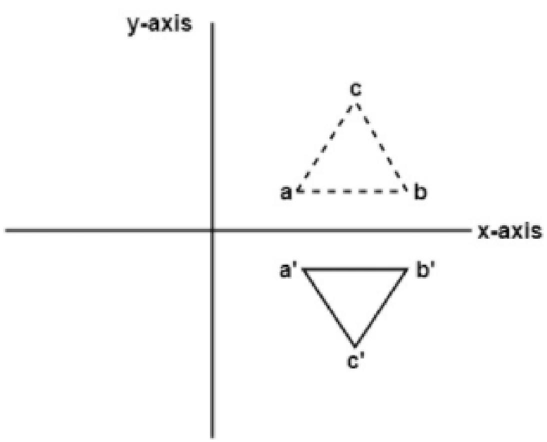
Types of Reflection:

1. Reflection about the x-axis
2. Reflection about the y-axis
3. Reflection about an axis perpendicular to xy plane and passing through the origin
4. Reflection about line y=x

1. Reflection about x-axis: The object can be reflected about x-axis with the help of the following matrix

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

In this transformation value of x will remain same whereas the value of y will become negative. Following figures shows the reflection of the object axis. The object will lie another side of the x-axis.



Shearing:

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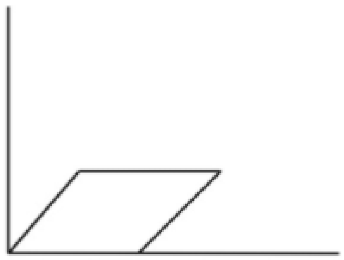
It is transformation which changes the shape of object. The sliding of layers of object occur. The shear can be in one direction or in two directions.

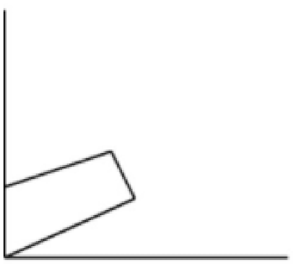
Shearing in the X-direction: In this horizontal shearing sliding of layers occur. The homogeneous matrix for shearing in the x-direction is shown below:

$$\begin{bmatrix} 1 & 0 & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

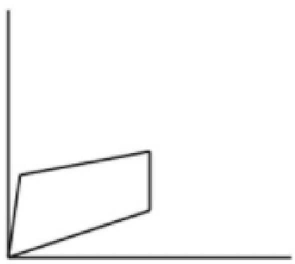
Original Object



Shear in X direction



Shear in Y direction



Shear in both directions

Shearing in the Y-direction: Here shearing is done by sliding along vertical or y-axis.

$$\begin{bmatrix} 1 & Sh_y & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Shearing in X-Y directions: Here layers will be slided in both x as well as y direction. The sliding will be in horizontal as well as vertical direction. The shape of the object will be distorted. The matrix of shear in both directions is given by:

$$\begin{bmatrix} 1 & Sh_y & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Composite Transformation

Composite Transformation:

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A number of transformations or sequence of transformations can be combined into single one called as composition. The resulting matrix is called as composite matrix. The process of combining is called as concatenation.

Suppose we want to perform rotation about an arbitrary point, then we can perform it by the sequence of three transformations

1. Translation
2. Rotation
3. Reverse Translation

The ordering sequence of these numbers of transformations must not be changed. If a matrix is represented in column form, then the composite transformation is performed by multiplying matrix in order from right to left side. The output obtained from the previous matrix is multiplied with the new coming matrix.

Example showing composite transformations:

The enlargement is with respect to center. For this following sequence of transformations will be performed and all will be combined to a single one

Step1: The object is kept at its position as in fig (a)

Step2: The object is translated so that its center coincides with the origin as in fig (b)

Step3: Scaling of an object by keeping the object at origin is done in fig (c)

Step4: Again translation is done. This second translation is called a reverse translation. It will position the object at the origin location.

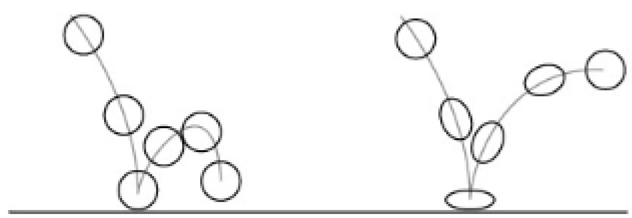
Squash and Stretch

What is Squash and Stretch?

Squash and Stretch (S&S for short) is the principle of applying a contrasting change of shape—from a squash pose to a stretch pose or vice versa—to give a feeling of fleshiness, flexibility, and life in animation. The absence of squash and stretch gives a rigidity or stiffness to the motion. The transition between a proper Squash pose to a Stretch pose, or the other way around, breaks the perfect solidity that CG animation in particular inherently gives to everything.

Squash and Stretch In Action

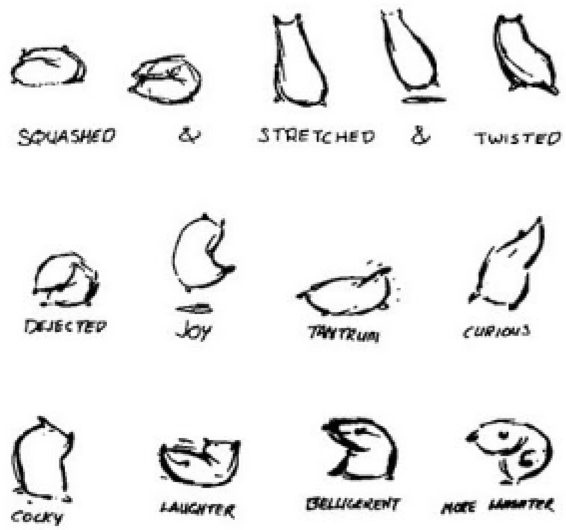
Here the principle of S&S is boiled down to it's essence on the classic Bouncing Ball. There is a Squash pose on the drawing where the ball is in contact with the ground, and Stretch poses just before and after it to provide the necessary contrast.



The classic bouncing ball with and without Squash and Stretch.

Why do animators need Squash and Stretch?

Squash and Stretch can make characters and inanimate objects have a feeling of life by introducing a flexible quality. S&S can be applied to a single body part, say an eyeball, or the entire character's pose. The latter is particularly useful when making rigid objects come to life, like the classic Disney Flour Sack, which is a beginning traditional animator's test case.



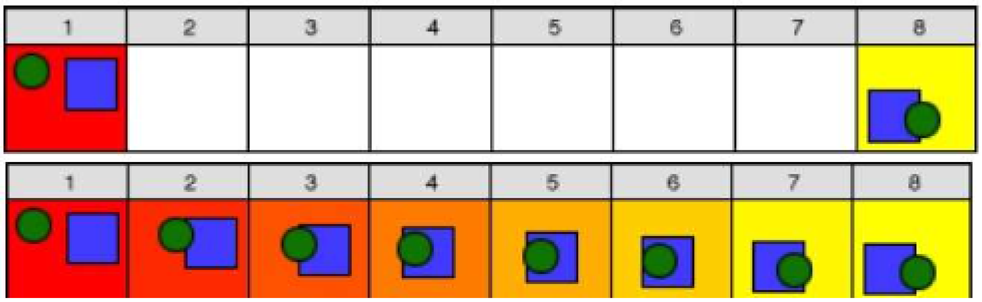
Disney Four Sack Model Sheet, Note: Squash and Stretch Poses

Key-Framing

Key Framing

A keyframe is a frame where we define changes in animation. Every frame is a keyframe when we create frame by frame animation. When someone creates a 3D animation on a computer, they usually don't specify the exact position of any given object on every single frame. They create keyframes.

Keyframes are important frames during which an object changes its size, direction, shape or other properties. The computer then figures out all the in-between frames and saves an extreme amount of time for the animator. The following illustrations depict the frames drawn by user and the frames generated by computer.



Motion Capture

Performance Based $MotionCapture$

Another technique is Motion Capture, in which magnetic or vision-based sensors record the actions of a human or animal object in three dimensions. A computer then uses these data to animate the object.

This technology has enabled a number of famous athletes to supply the actions for characters in sports video games. Motion capture is pretty popular with the animators mainly because some of the commonplace human actions can be captured with relative ease. However, there can be serious discrepancies between the shapes or dimensions of the subject and the graphical character and this may lead to problems of exact execution.

Input and Output Devices in Computer Graphics

Input Devices:

1. Keyboard
2. Mouse

3. Joystick
4. Light Pen
5. Scanner
6. OCR
7. Bar-Code Reader
8. Web Camera

Output Devices:

1. Monitor
2. Printer

Animation and its types

What is animation?

Animation is a method of photographing successive drawings, models, or even puppets, to create an illusion of movement in a sequence. Because our eyes can only retain an image for approx. 1/10 of a second, when multiple images appear in fast succession, the brain blends them into a single moving image. In traditional animation, pictures are drawn or painted on transparent celluloid sheets to be photographed. Early cartoons are examples of this, but today, most animated movies are made with computer-generated imagery or CGI.

To create the appearance of smooth motion from these drawn, painted, or computer-generated images, frame rate, or the number of consecutive images that are displayed each second, is considered. Moving characters are usually shot "on twos" which just means one image is shown for two frames, totaling in at 12 drawings per second. 12 frames per second allows for motion but may look choppy. In the film, a frame rate of 24 frames per second is often used for smooth motion.

Different Types of Animation:

- Traditional Animation
- 2D Animation (Vector-based)
- 3D Animation
- Motion Graphics
- Stop Motion

Traditional

This is one of the oldest forms of animation in film. It's sometimes called cel animation. As mentioned above, in traditional animation, objects are drawn on celluloid transparent paper. In order to create the animated sequence, the animator must draw every frame. It's the same mechanism as a flipbook, just on a grander scale.

Traditional is most often 2D animation. *Aladdin*, *The Lion King*, and other earlier cartoons are the best examples of this. *Though, not all 2D is traditional. But we'll get to that in a minute.

2D (Vector)

2D animation can fall under traditional animation like most early Disney movies — *Pinocchio*, *Beauty and the Beast*, etc. But there is something called Vector-based animation that can be 2D without being traditional.

With Vector-based, the motion here can be controlled by *vectors* rather than *pixels*. So, what the heck does that mean?

Images with familiar formats like JPG, GIF, BMP, are pixel images. These images cannot be enlarged or shrunk without affecting image quality. Vector graphics don't need to worry about resolution. Vectors are characterized by pathways with various start and end points, lines connecting these points to build the graphic. Shapes can be created to form a character or other image. Below is an example.

3D

Today, 3D or computer animation is the most common type. But just because computers have stepped in instead of actual drawings, it's not necessarily easier. The computer is just another tool, and 3D animation is still a long, intense process.

In 3D animated movies, the animator uses a program to move the character's body parts around. They set their digital frames when all of the parts of the character are in the right position. They do this for each frame, and the computer calculates the motion from each frame.

Animators adjust and tweak the curvatures and movements their characters make throughout. From *Toy Story* in 1995 to today's *Coco*, 3D animation has become the dominant style in animated films.

Motion Graphics

Motion Graphics are pieces are digital graphics that create the illusion of motion usually for ads, title sequences in films, but ultimately exist to communicate something to the viewer. They're often combined with sound for multimedia projects.

They're a type of animation used mostly in business, usually with text as a main player. Below are a few examples of motion graphic animation, using the top trends of today.

Stop Motion

Stop motion encompasses claymation, pixelation, object-motion, cutout animation, and more. But the basic mechanics are similar to the traditional style like a flipbook. However, instead of drawings, stop motion adjusts **physical objects** in each frame.

If moved in small increments, captured one frame at a time, the illusion of motion is produced. Whether puppets, clay, or even real people, these manual adjustments can make it a long, arduous process. *Wallace and Gromit*, *Chicken Run*, and *The Nightmare Before Christmas* are all great examples of stop motion films.