UNIT – 4

Representing Curve and Polygon Surfaces

★ **Polygon :-** A polygon is any 2-dimensional shape formed with straight line. Triangle, rectangle, pentagon, hexagon etc are the examples of polygon.

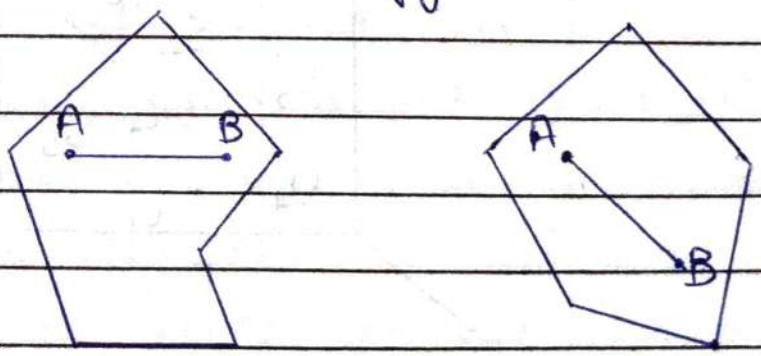
Polygon is a closed shape with straight sides. The word polygon came from the Greek like most term in geometry. Simple means of polygon poly → many and gon → angle.

There are 2 types of polygon in computer graphics –

(i) Convex

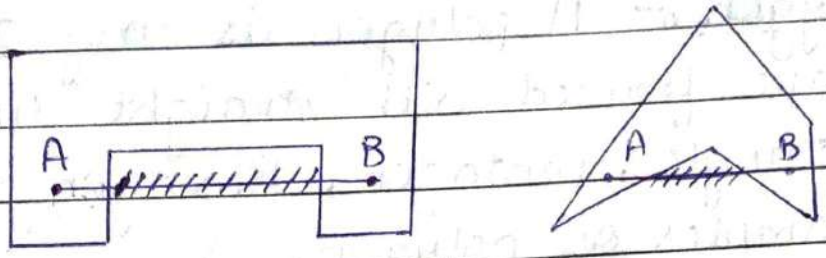
(ii) Concave

1- **Convex –** If the line connecting two interior points of the polygon lies completely inside the polygon, it is said to be convex. The respected points are inside the polygon.

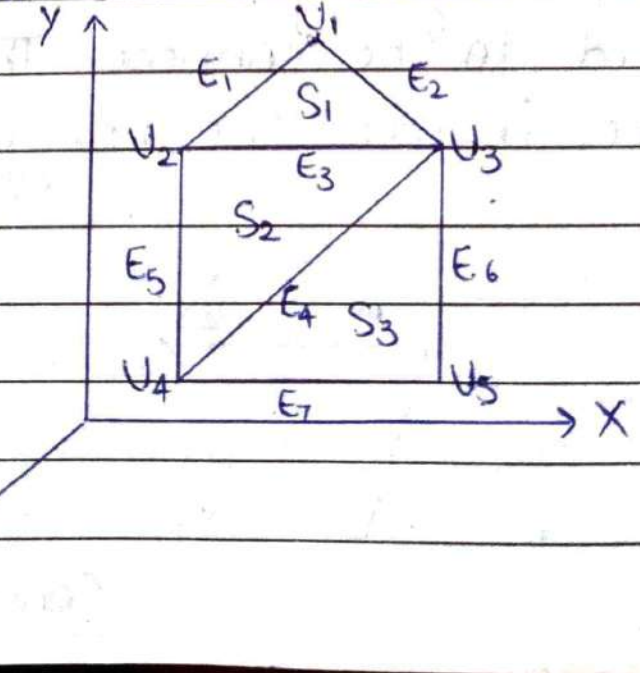


Convex

2. **Concave** – Line joining any two interior points of the polygon is not completely inside the polygon that are called concave.



* **Polygon table** :- The polygon table contain the all surface (vertex, edge and surface) information about the polygon with set of coordinate and associated parameter. Geometric table contain vertex coordinate and parameter to specify the orientation of the polygon surface. Attribute information for an object include parameter specify the degree of transparency of the object and its surface reflect and texture characteristics.

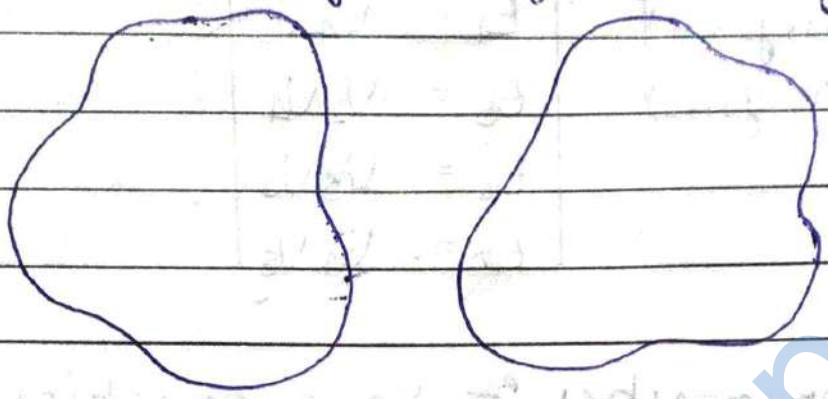


Vertex table	Edge table	Surface table
$V_1 = (x_1, y_1, z_1)$	$E_1 = V_1V_2$	$S_1 = E_1E_2E_3$
$V_2 = (x_2, y_2, z_2)$	$E_2 = V_1V_3$	$S_2 = E_3E_5E_4$
$V_3 = (x_3, y_3, z_3)$	$E_3 = V_2V_3$	$S_3 = E_4E_6E_7$
$V_4 = (x_4, y_4, z_4)$	$E_4 = V_4V_3$	
$V_5 = (x_5, y_5, z_5)$	$E_5 = V_2V_4$	
	$E_6 = V_3V_5$	
	$E_7 = V_4V_5$	

* **Polygon meshes :-** Some graphics package provide several polygon function for modelling object. A single plane surface can be specify with functions such as fill area but when object surface are to tiled. It is more easy to specify the surface facts with a mesh function. A type of polygon mesh is the minimum triangle tree. When polygon mesh specify with more than 3 vertices it is possible that vertices may not lies on the plane.

* **Blobby object or curve in CG :-** Some object do not maintain a fixed shape but change their surface characteristics in certain position or when in approximity to other objects.
Example of these objects include molecular

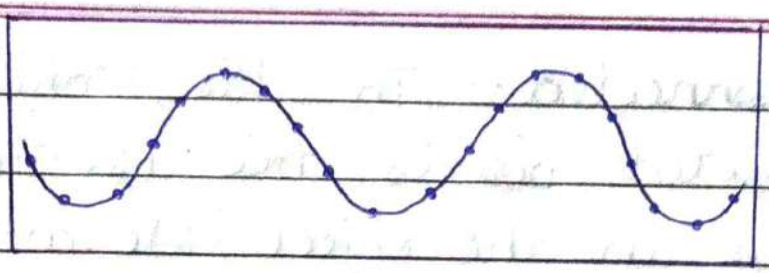
structure, water drops and other liquid effects. These objects can be described as a blobby object. Their shape show a certain degree of fluidity.



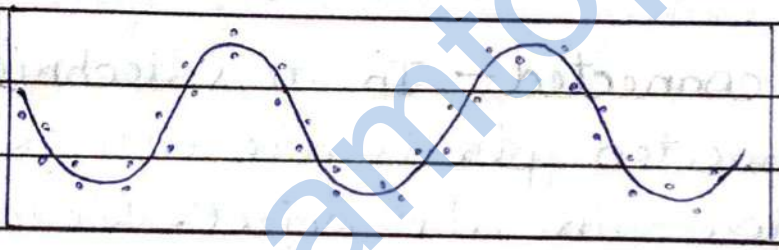
- **Curve representation** :- Curve representation is a method to identify the curved object is to be belong their respected pixels. There are basically two types of curve representation (SP line - Straight Point line).

1. Intropolation
2. Approximation

1- **Intropolation** – We specify a SP line curve by giving a set of coordinate position called control point which indicate the general shape of the curve. These control points are fitted piecewise. When polynomial section are fit on the control point, the result of curve is said to be intropolation.



2- **Approximation** – When a SP line curve are fitted to general control point path without passing through any control point (nearby of control point) the result curve is said to be approximation. Approximation SP line curve do not pass (touch) the control-point.



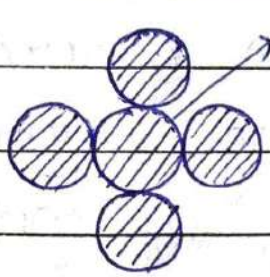
★ **Boundary fill algorithm :-** Boundary fill algorithm works as its name. This algorithm pick a point inside the object and start to fill until it touch the boundary of the object. The colour of the boundary, we assume same as well as object and boundary.

There are 2 methods of boundary fill algorithm use to fill the colour in the object -

4- connected

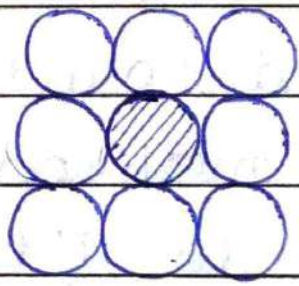
8- connected

1. 4-connected – In this technique four connected pixels are use to fill the colour in the object. We are putting the pixel of entire pixel to above, behind, top and bottom.



And this process will continue until we find the boundary of object.

2. 8-connected – In this technique, eight-connected pixels are use to fill the colour in the object. We are putting pixel above, below, right and left side of the current entire pixel as we use in 4-connected technique. In addition to this we are also putting pixel in diagonals so then entire area of the current pixel is completely covered.



Algorithm –

Step 1 – Choose a random entire point which is consider object.

Step 2 – Each pixel to the left, right, top and bottom are tested (covered).

Step 3 – Repeat process until all pixels upto the boundary colour all the area have been tested (covered).

★ Absolute Polygon Algorithm :- In absolute polygon algorithm, these steps include –

Step 1 – Input the array containing the vertices of the polygon.

Step 2 – Identify the all number of sides of polygon.

Step 3 – Coordinate of current point position and a vertical stepping of the polygon side.

Step 4 – Check the number of vertices of all side that is greater than 3 or equal to 3.

Step 5 – Finally enter the instruction for the sides (vertices and edges) and return.

Flood Fill Algorithm

Introduction :- Flood fill, also called seed fill, is an algorithm that determines the area connected to a given node in a multi-dimensional array. It is used in the "bucket" fill tool of paint programs to fill connected, similarly-colored areas with a different color.

Concept :-

- Flood fill colors an entire area in an enclose figure through interconnected pixels using a single color.
- It is an easy way to fill color in the graphics. One just take the shape and starts flood fill.
- The algorithm works in a manner so as to give all the pixels inside the boundary the same color, leaving the boundary and pixels outside.
- By this algorithm, we can recolor an area that is not defined within a single color boundary.

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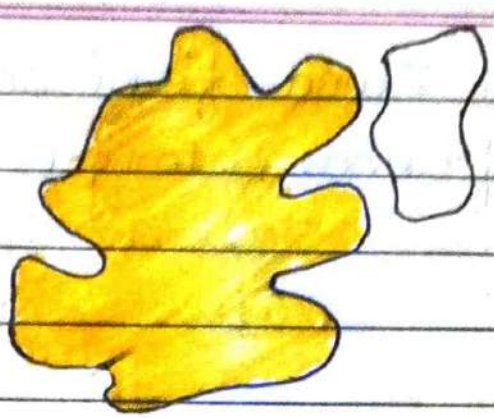

Flood fill

Algorithm :- The flood fill algorithm takes three parameters : a start node, a target color and a replacement color. The algorithm looks for all nodes in the array that are connected to the start node by a path of the target color and changes them to the replacement color.

Flood-fill (node, target-color, replacement-color)

1- If target-color is equal to replacement-color, return.

2- If the color of node is not equal to target-color, return.

3- Set the color of node to replacement-color.

4- Perform Flood-fill (one step to the south of node, target color, replacement-color.
Perform Flood-fill (one step to the north of node, target-color, replacement-color.
Perform Flood-fill (one step to the west

Perform Flood-fill (one step to the east of node, target-color, replacement-color).

5- Return.

Methods :- There are many ways in which the flood-fill algorithm can be structed, but they all make use of a queue or stack data structure, explicitly or implicitly.
Depending on whether we consider nodes touching at the corners connected or not, we have two variations — eight way and four-way respectively.

4-way recursive method — You call the function within its parameters : the start position, the oldcolor and the newcolor. Each seed gives the pixel at its position the new color, and then plants a new seed at its 4 neighbors.

8-way recursive method — This method is similar to the previous one, except it doesn't test 4 neighbors, but 8.

★ **Curve** :- A curve is an infinitely large set of points, Each point has two neighbour except end points, Curve can be broadly define in 3 categories -

1. Implicit
2. Explicit
3. Parametric

1- Implicit curve - Implicit curve represent define a set of points on a curve by employing a procedure that can test to see if a point is on the curve. Usually implicit curve is define by the function

$$\boxed{f(x,y) = 0}$$

It can represent multi-value curve (multiple value of x and y). Implicit curve representation is -

$$x^2 + y^2 - R^2 = 0$$

or $$\boxed{x^2 + y^2 = R^2}$$

2. Explicit curve - A mathematical function $y = f(x)$ can be plotted explicit curve. The explicit representation is not general function, since it cannot represent vertical lines and is also single value with the respect of x and y.

3- Parametric curve — Curve have parametric form are called parametric curve. The explicit and implicit curve representation can be used only when the function is given, but in parametric curve we calculate the functions with the help of parameter translation (t).

$$P(t) = f(t), g(t)$$

* **Bezier Curve** :- Bezier curve is discovered by French engineer Pierre Bezier. These curve can be generated under the control of other points. Approximation curve is using as a control point in this method.

$$\sum_{K=0}^{n} P_i B_i^n(t)$$

where P_i = set of points

n = number of polygon degree

t = variable

B_i^n = Berstein Polygon

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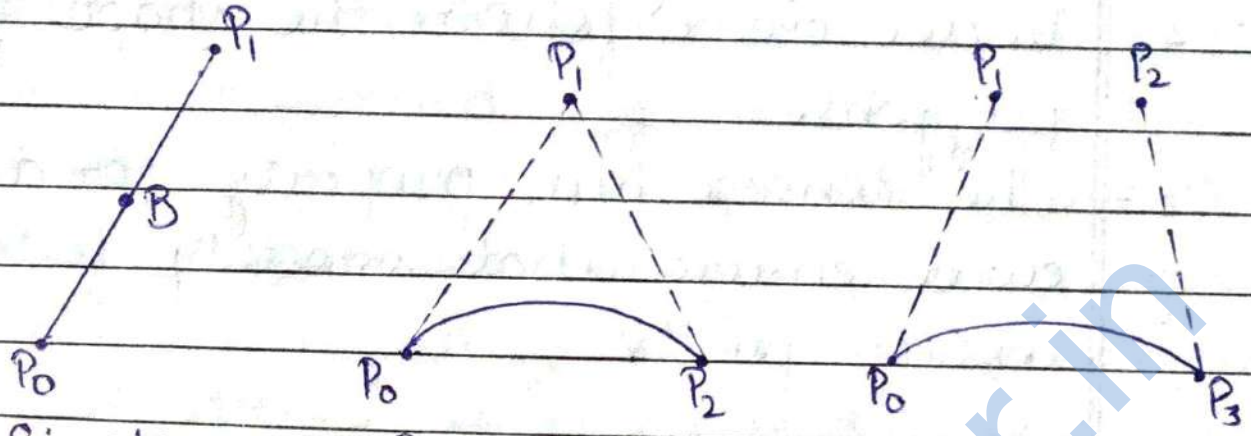
- Types of Berier Curve :-



Simple Berier Curve | Quardratic Berier Curve | Cubic Berier Curve

Simple Berier curve is denoted by a straight line with two control points P_0 and P_1.

Quardratic Berier curve contain 3 control points P_0, P_1 and P_2. In quardratic Berier curve we apply approximation method to calculate their coordinates.

Cubic Berier curve contain 4 control points P_0, P_1, P_2 and P_3. Cubic Berier curve also apply approximation method to calculate the coordinates of a cube.

- Properties of Berier Curve —

1- Berier curve generally follow the shape of control polygons, which consist of segments joining with the control points.

2- They always pass through the first and last control points.

3- They are contain in the convex hull of

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their defining control points.

4- Bezier curve follow the shape of defining polygons.

5- The convex hull property for a bezier curve ensure that smoothly follow all control points.

★ **Quadric Surface :-**

A frequently used class of objects are the quadric surface which are described with second degree equation (quardratic). They include spheres, ellipsoids, torus, paraboloids and hyperboloids. Quadric surface particularly spheres and ellipsoide are common element of graphic scene.

A quadric surface is the graph of second degree equation in the respect of 3 variables x, y and z. The most general equation used in quadric surface is -

$$Ax^2 + By^2 + Cz^2 + Dxy + Eyz + Fzx + Gx + Hy + Iz + k$$

★ **Solid modeling :-**

Solid modeling is the representation of solid part of an object which is visible on your computer screen. Providing surface representation with 3- dimension (3D) view

of geometric model make the object solid on computer screen.

Solid modeling is the most advanced method of geometric modeling in 3-dimension. Graphic scenes can contain many different kind of objects like — tree, flower, cloud, rocks-water, bricks, paper books etc.

- Advantages of solid modeling —
Solid modeling concept use to draw solid objects in computer graphics. Some softwares like CAD use it. The solid modeling CAD software help the designer to see the designed object as if it were the real world manufacturing product. It can be seen from various directions and various views.
This help the designer to be sure that the object look like as well as it want to be draw.

- Process of making the solid-model — To make the solid model object you have to first make the wire frame model of the object and convert it into 3-D view. Thereafter the surface are added to the 3-D wire model convert it into 3-D

solid model.

- Applications of solid modeling – Solid modeling is not only used in creating solid objects but it also used in creating demo of buildings, electric circuits and even of the human beings. Solid modeling is also used in engineering, entertainment industry and medical sector.

- Boundary Representation (B-Rep) – Boundary representation a 3-dimensional object as a set of surface that seperate the objects interior point from the exterior point environment. It is a method for representing shapes using the limits of boundary control points. A B-Rep is represent as a collection of connected surface element.

- Space partitioning Representation – Space partition representation are use to describe interior points properties by partition of region containing an object into a set to small, none overlapping, contigous solid. A common space partition description for a 3-D

object is an octree representation. Hierarichal tree structure is called octree are used to represent solid object in some graphic system. Medical imagine and other applications that require display of object cross section commonly use octree representation. The octree structure is organise so that each node (control points) correspond to a region of 3-dimensional space.

- Sweep Representation —

Sweep Representations are useful for constructing three-dimensional objects that passes translational, rotational, or other symmetries. We can represent such objects by specifying a two-dimensional shape and a sweep that moves the space through a region of space.

Example- A prism can be generated using a translation sweep and rotational sweeps can be used to create curved surfaces like an ellipsoid or a torus.

More complex objects can be formed by using more complex transformations.