TOOL PATH PLANNING FOR FACE MILLING OF 3-D SURFACE

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Tessellated representation

- To fabricate any design, the 3-D model (surface or solid) has to be transferred to STL (Standard Tessellation Language) format.
- The STL file format is generated using a tessellation process, which generates triangles to represent the CAD model.
- The STL model is mathematically sliced by intersecting it with horizontal planes. Each slice represents a cross-section data for the part.

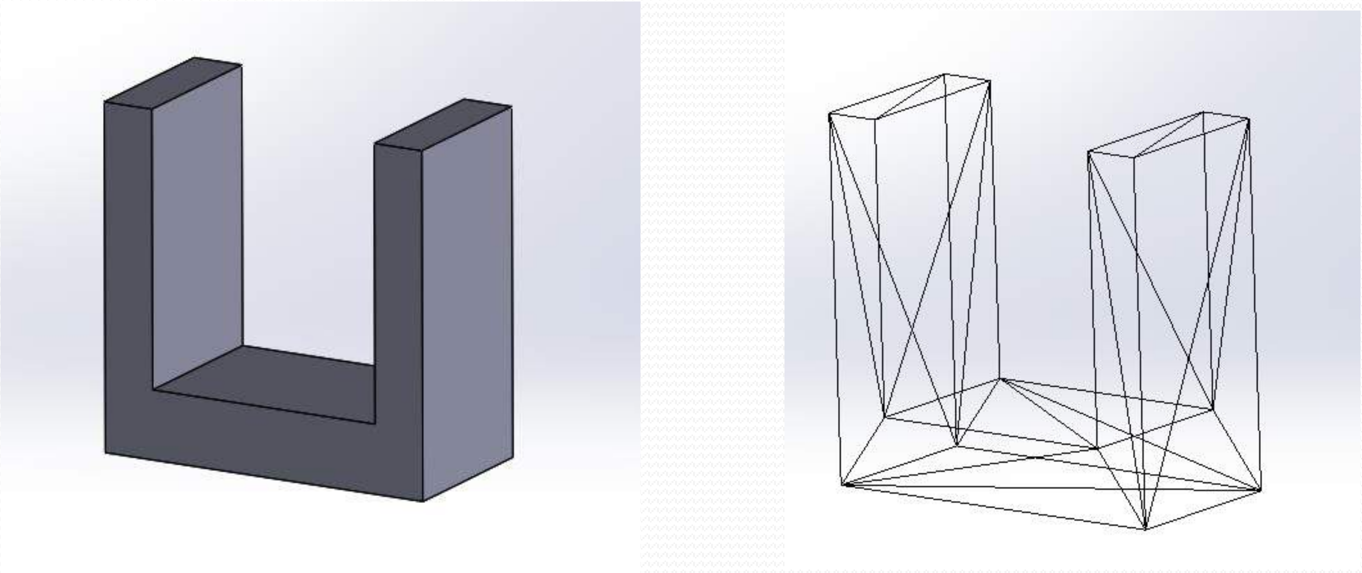


Figure 1: An object and its tessellated representation

- These triangles are described by a set of X, Y and Z coordinates for each of three vertices, and a unit normal vector to indicate which side of the triangle contains the mass.
- STL file can be in ASCII or in binary format.

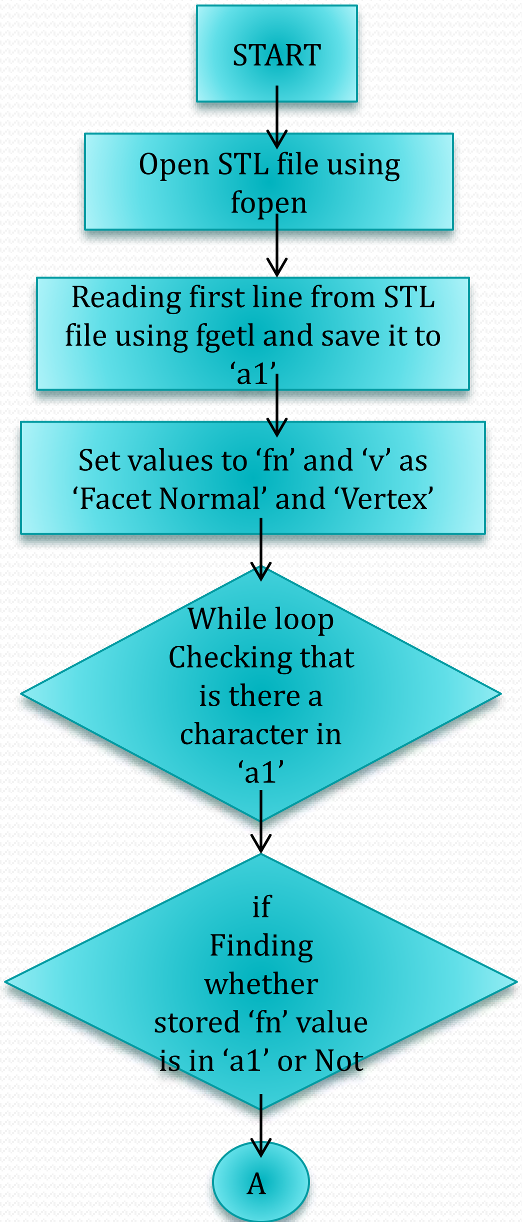
```
solid u_shape
   facet normal 0.000000e+00 0.000000e+00 -1.000000e+00
      outer loop
         vertex 0.000000e+00 5.000000e+01 0.000000e+00
         vertex 1.000000e+02 5.000000e+01 0.000000e+00
         vertex 0.000000e+00 0.000000e+00 0.000000e+00
      endloop
   endfacet
```

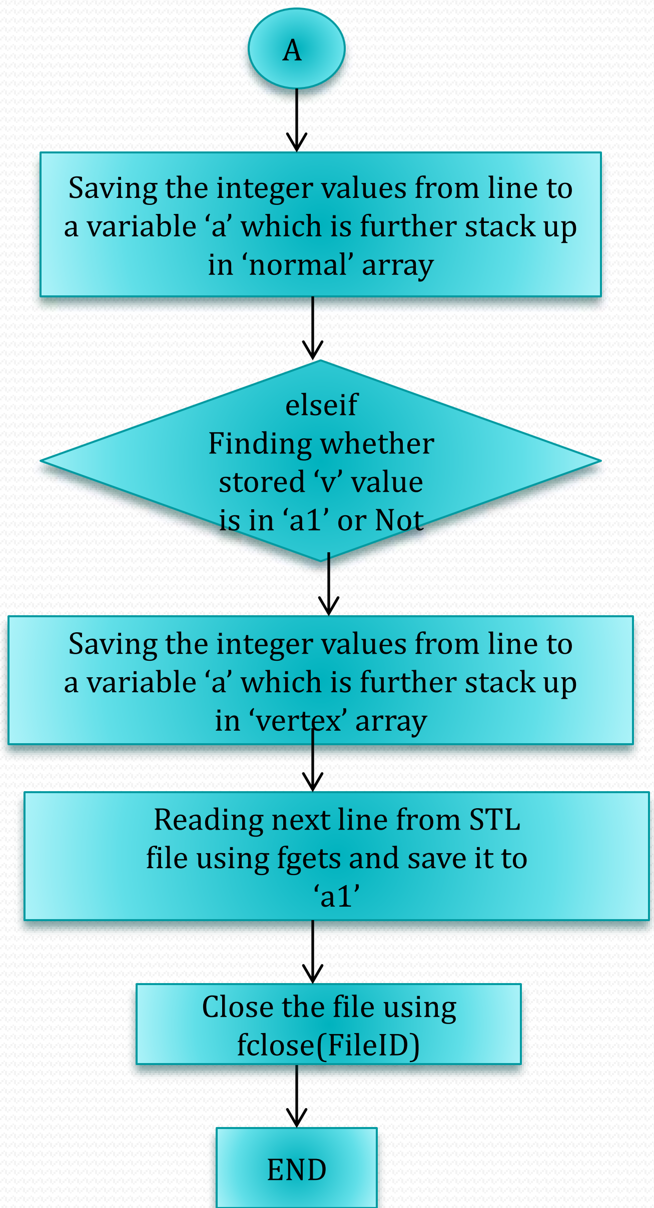
Fig 2- : STL File and description of ASCII representation format

OBJECTIVE

- To develop a tool path plan using STL format of 3D object by slicing the model.

Reading STL file




A
Saving the integer values from line to a variable ‘a’ which is further stack up in ‘normal’ array
elseif
Finding whether stored ‘v’ value is in ‘a1’ or Not
Saving the integer values from line to a variable ‘a’ which is further stack up in ‘vertex’ array
Reading next line from STL file using fgets and save it to ‘a1’
Close the file using fclose(FileID)
END

Slicing the model

- Find the Cutting Plan (Zc)

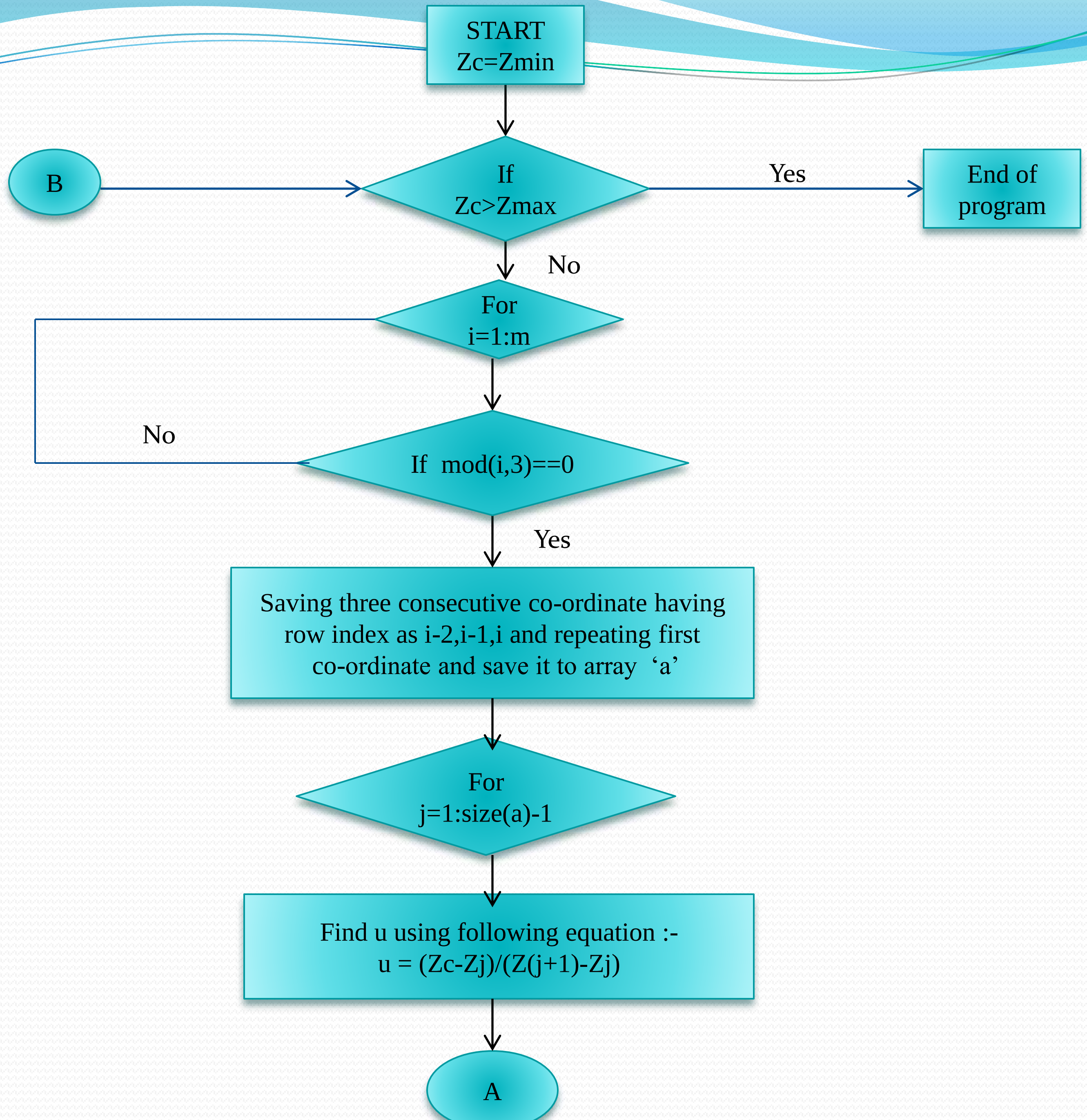
  The program scans STL file, picks the Z-coordinate of all the triangle, compare, and find the top, the bottom of the geometric (Zmin, Zmax), add the slice thickness to Zmin.

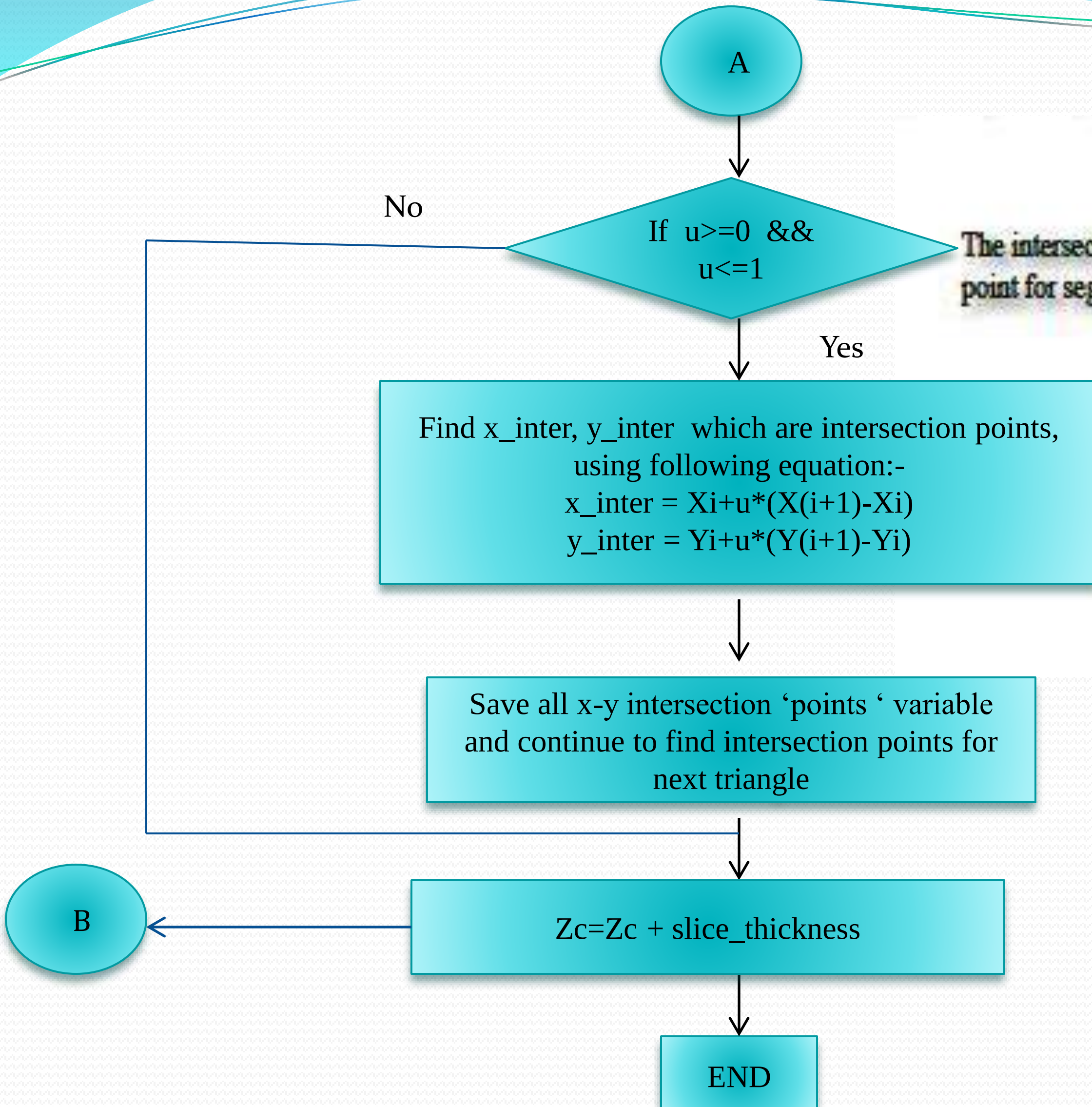
  Zc = Zmin + slice thickness

- Find the Facets that intersect with the Cutting Plan

  The program scans STL file to pick one triangle at a time, the Z-coordinate of its three vertices compared with the Z-height of the current plane,

  Zmin <= Zc <= Zmax , Zmin, Zmax are in one triangle


START
Zc=Zmin
B
If
Zc>Zmax
Yes
End of
program
No
For
i=1:m
No
If mod(i,3)==0
Yes
Saving three consecutive co-ordinate having
row index as i-2,i-1,i and repeating first
co-ordinate and save it to array ‘a’
For
j=1:size(a)-1
Find u using following equation :-
u = (Zc-Zj)/(Z(j+1)-Zj)
A



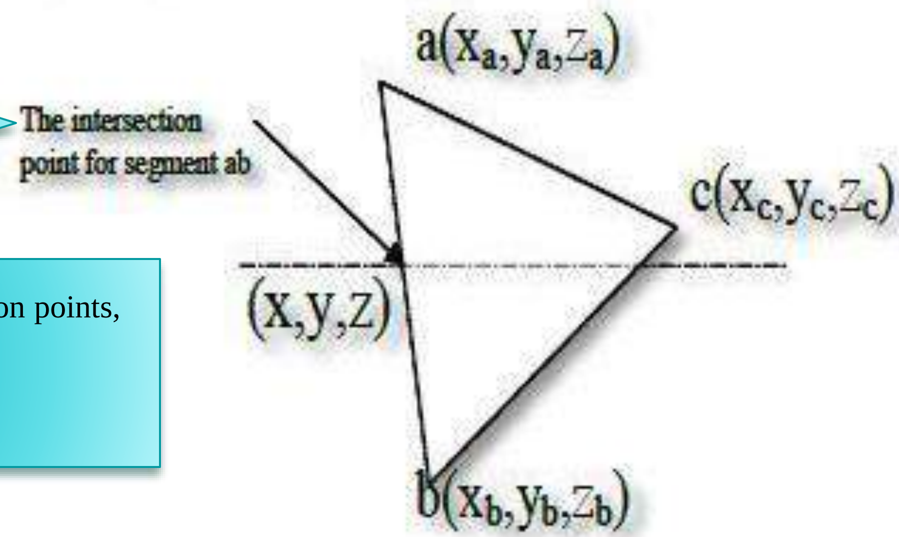


Fig. 3- Three vertices of one triangle and the intersection points

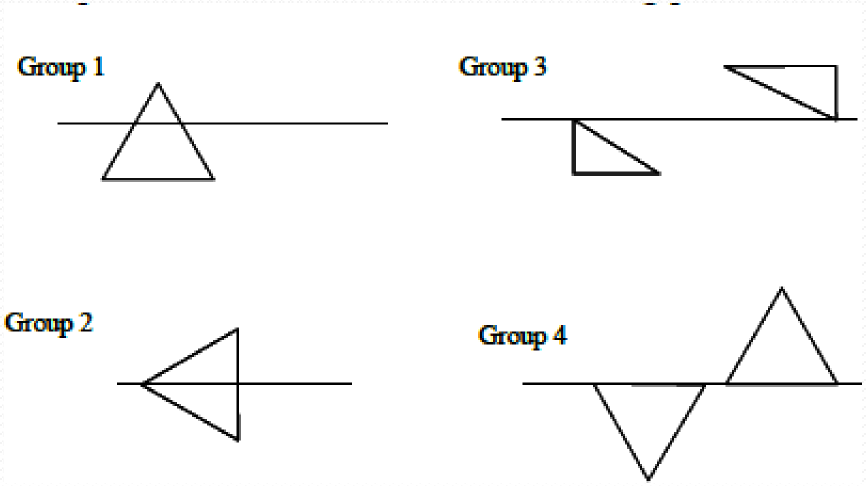


Fig. 3- The possible cases for triangle-plane slicing

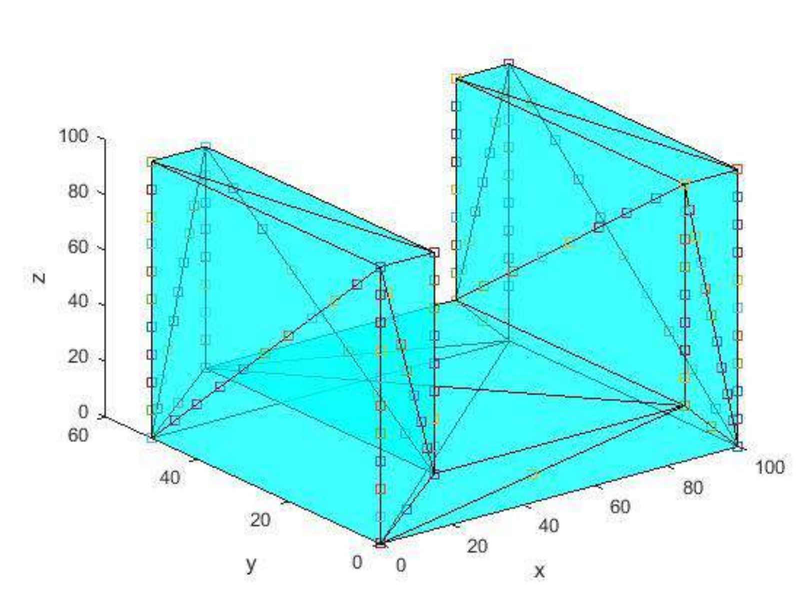
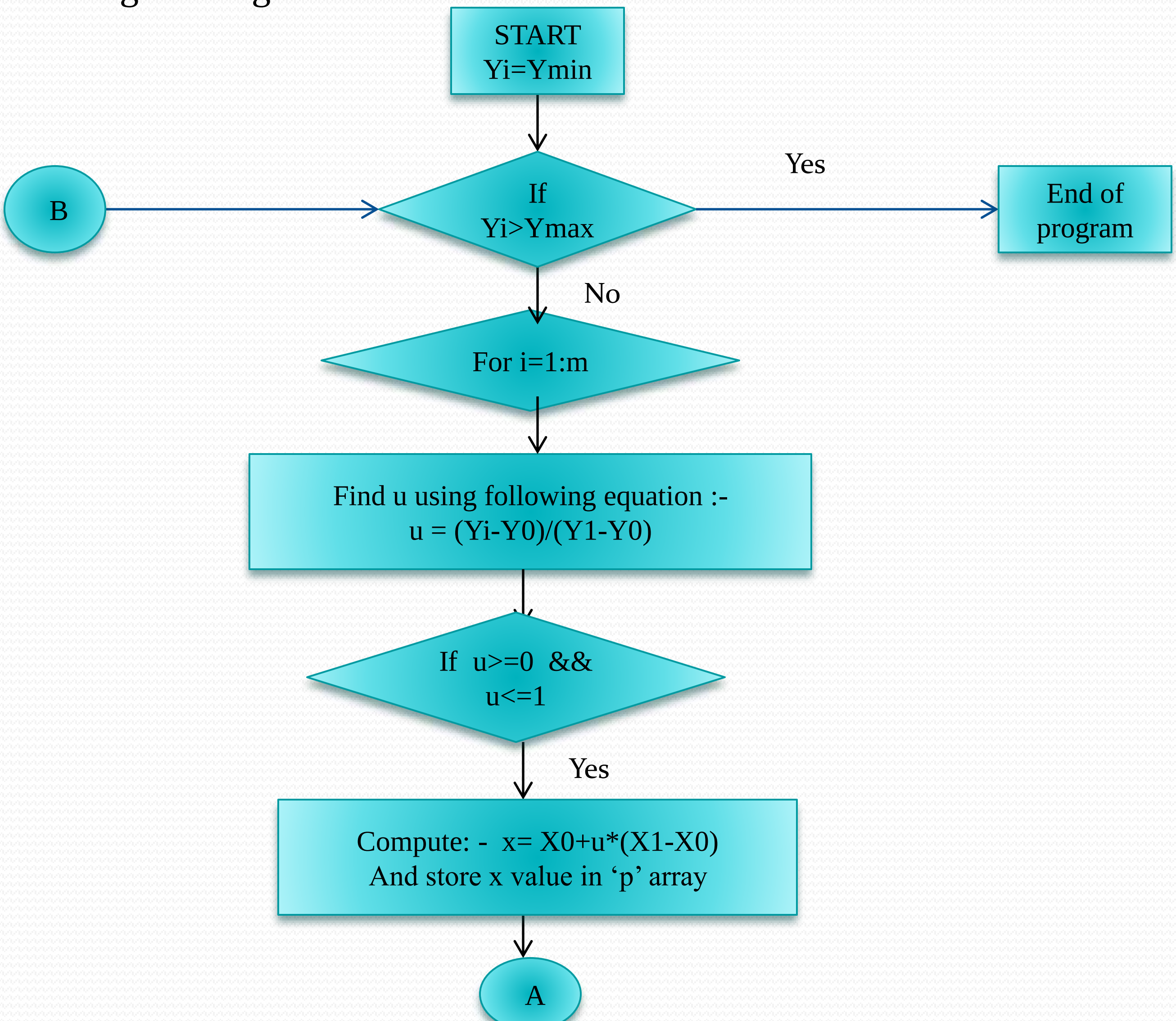
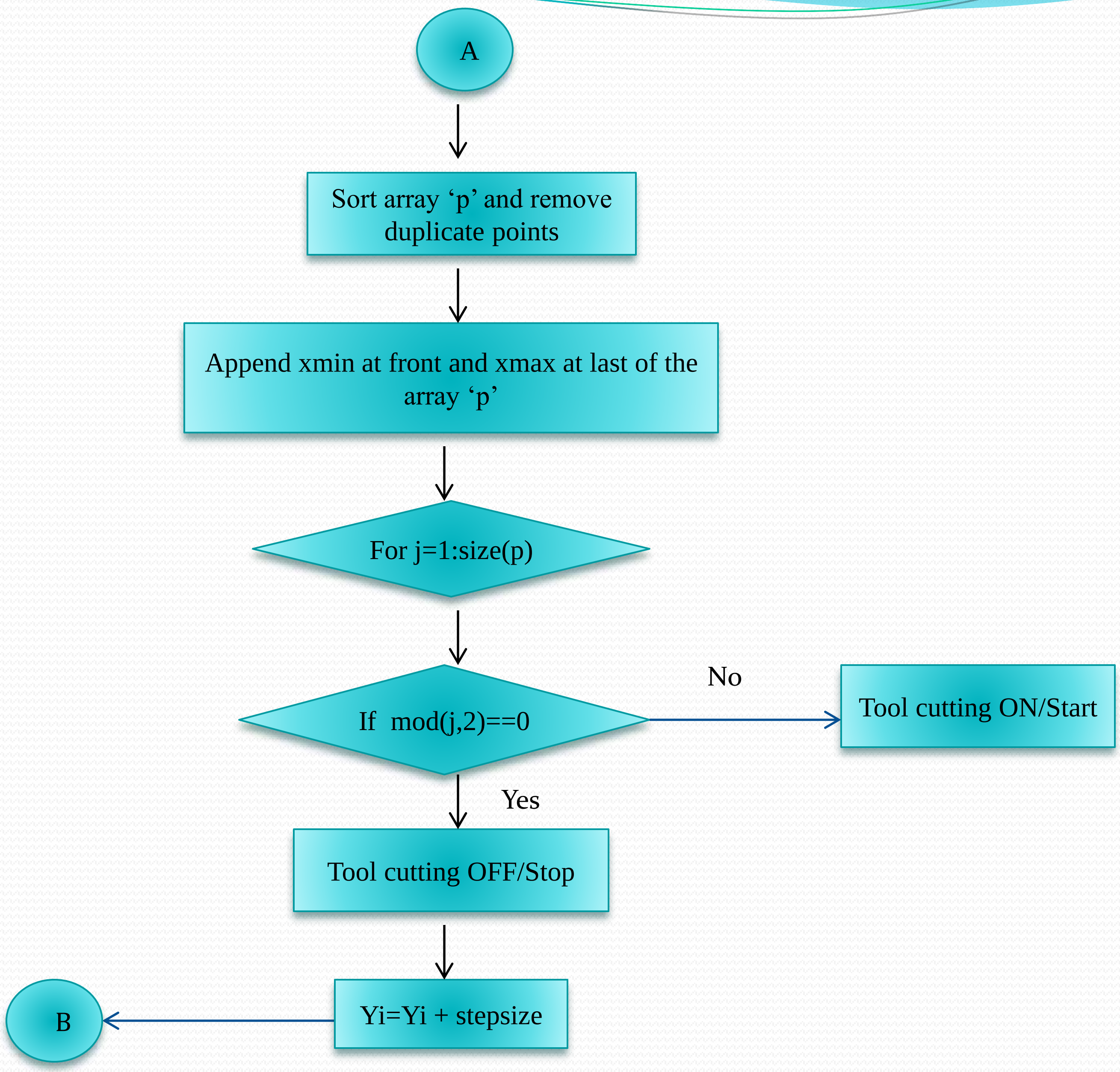


Fig. 4- Intersection points

Tool Path Algorithm

Let <L1{(X0,Y0),(X1,Y1)},L2{(X0,Y0),(X1,Y1)} ....Lm{(Xo,Yo),(X1,Y1)}> be array of intersecting line segments.




A
Sort array ‘p’ and remove duplicate points
Append xmin at front and xmax at last of the array ‘p’
For j=1:size(p)
If mod(j,2)==0
No
Tool cutting ON/Start
Yes
Tool cutting OFF/Stop
Yi=Yi + stepsize
B

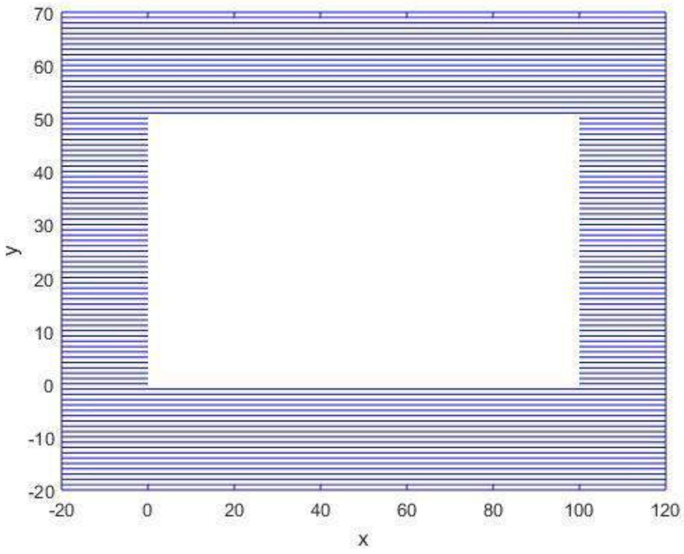


Fig..5- Zc=zmin

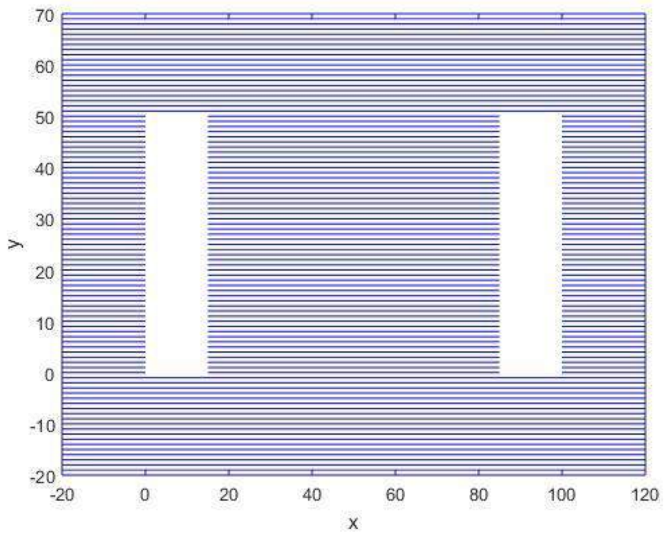


Fig..6- Zc=zmax

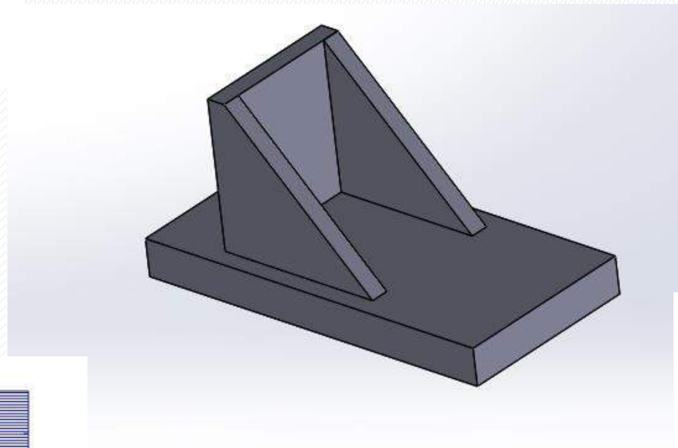
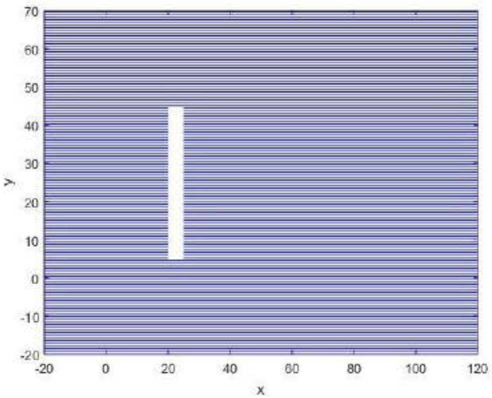
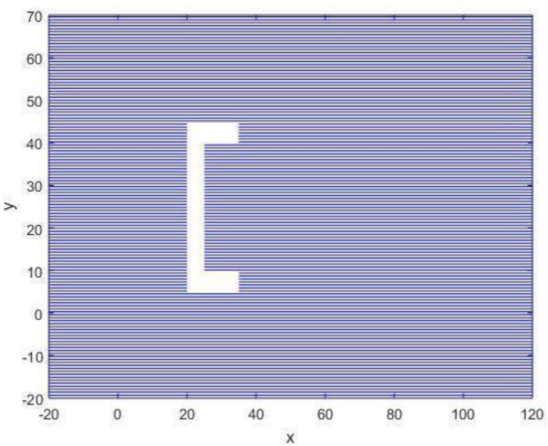


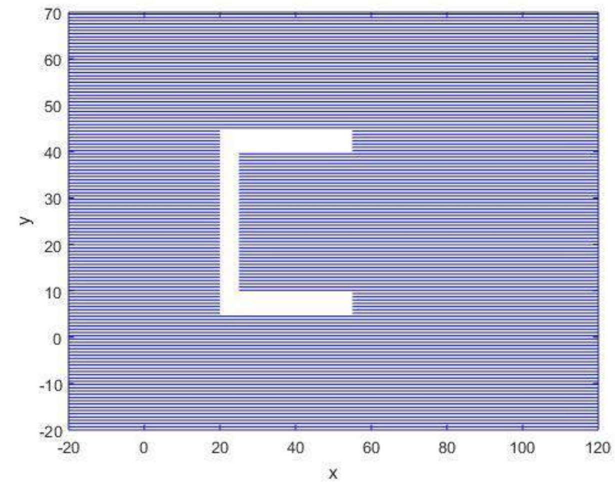
Fig.7 a) 3D model of bracket



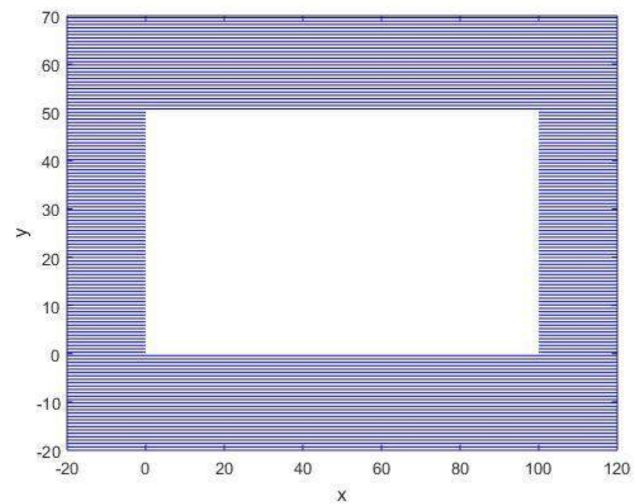
b) Zc=maxz



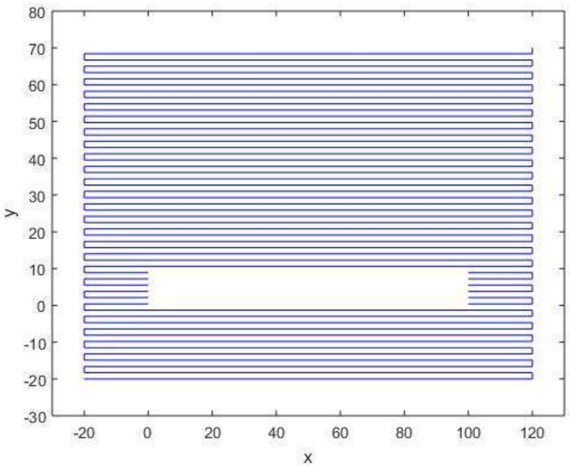
c) Zc=maxz-10



d) Zc=maxz-30



e) Zc=maxz-50



b) Zc=maxz

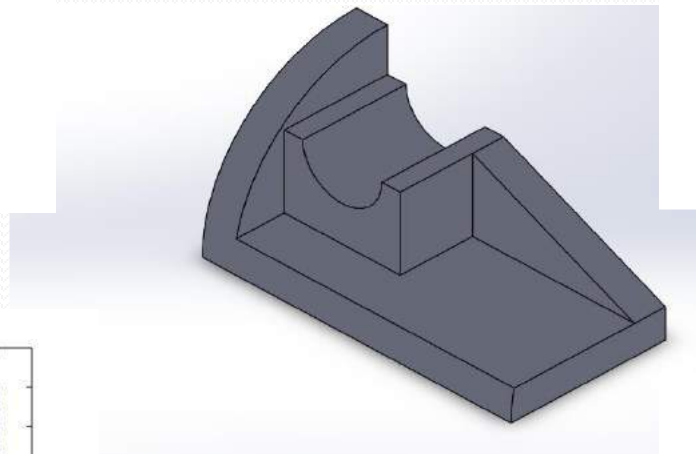
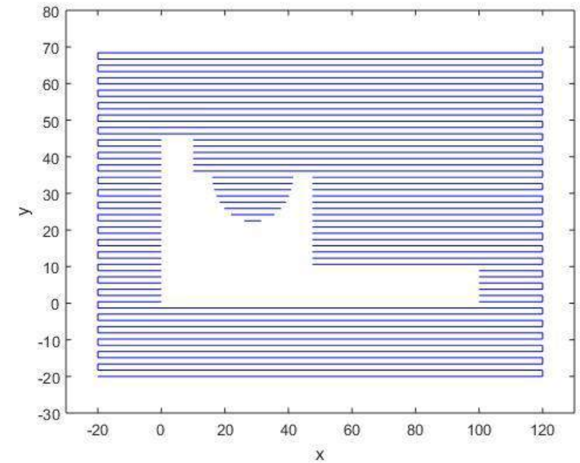
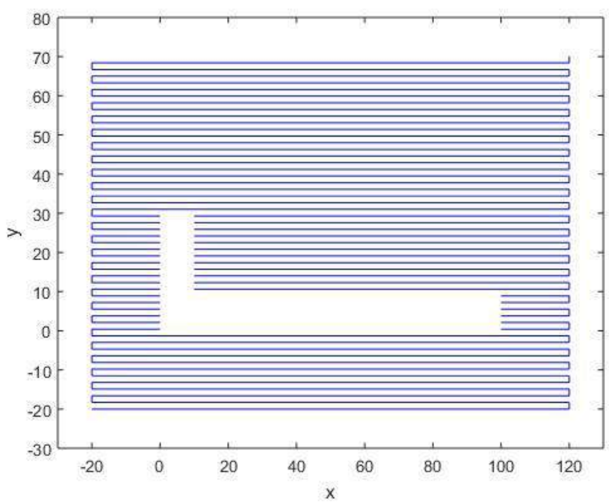


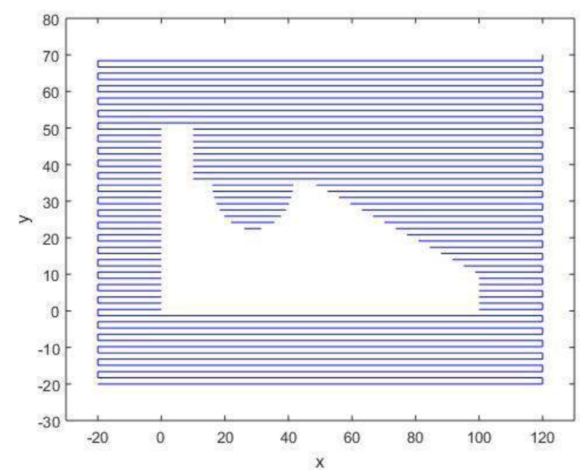
Fig. 8 a) 3D model of bracket



d) Zc=maxz-30



c) Zc=maxz-10



e) Zc=maxz-50

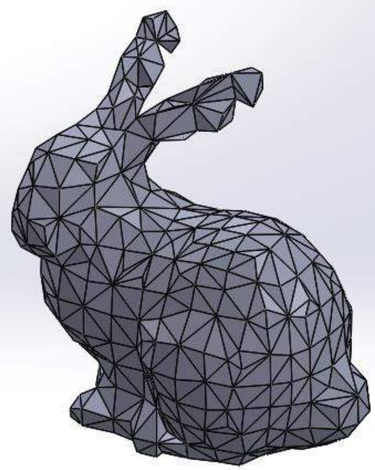
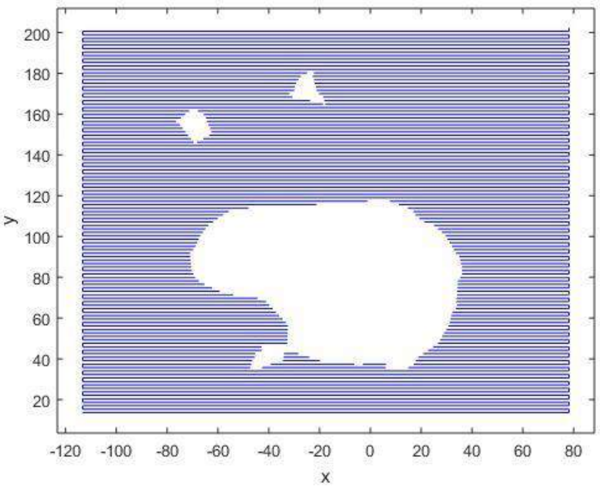
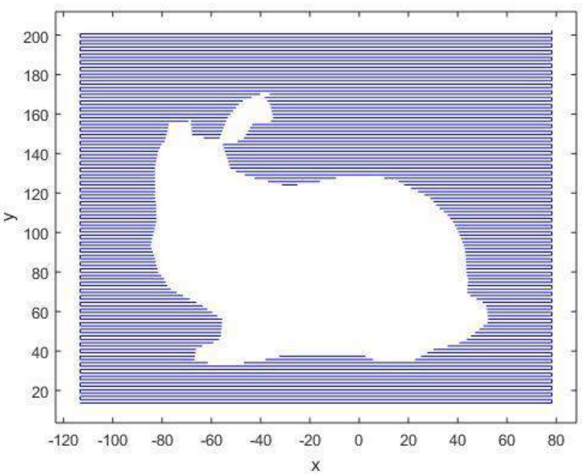


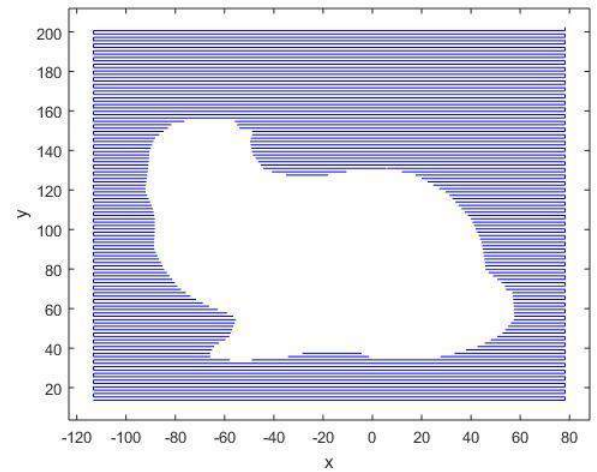
Fig. 9 a) 3D model of bunny



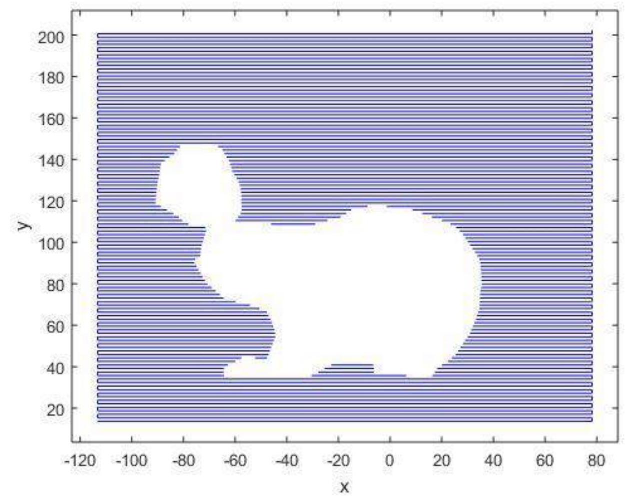
b) Zc=minz+40



c) Zc=minz+55



d) Zc=minz+70



e) Zc=minz+95

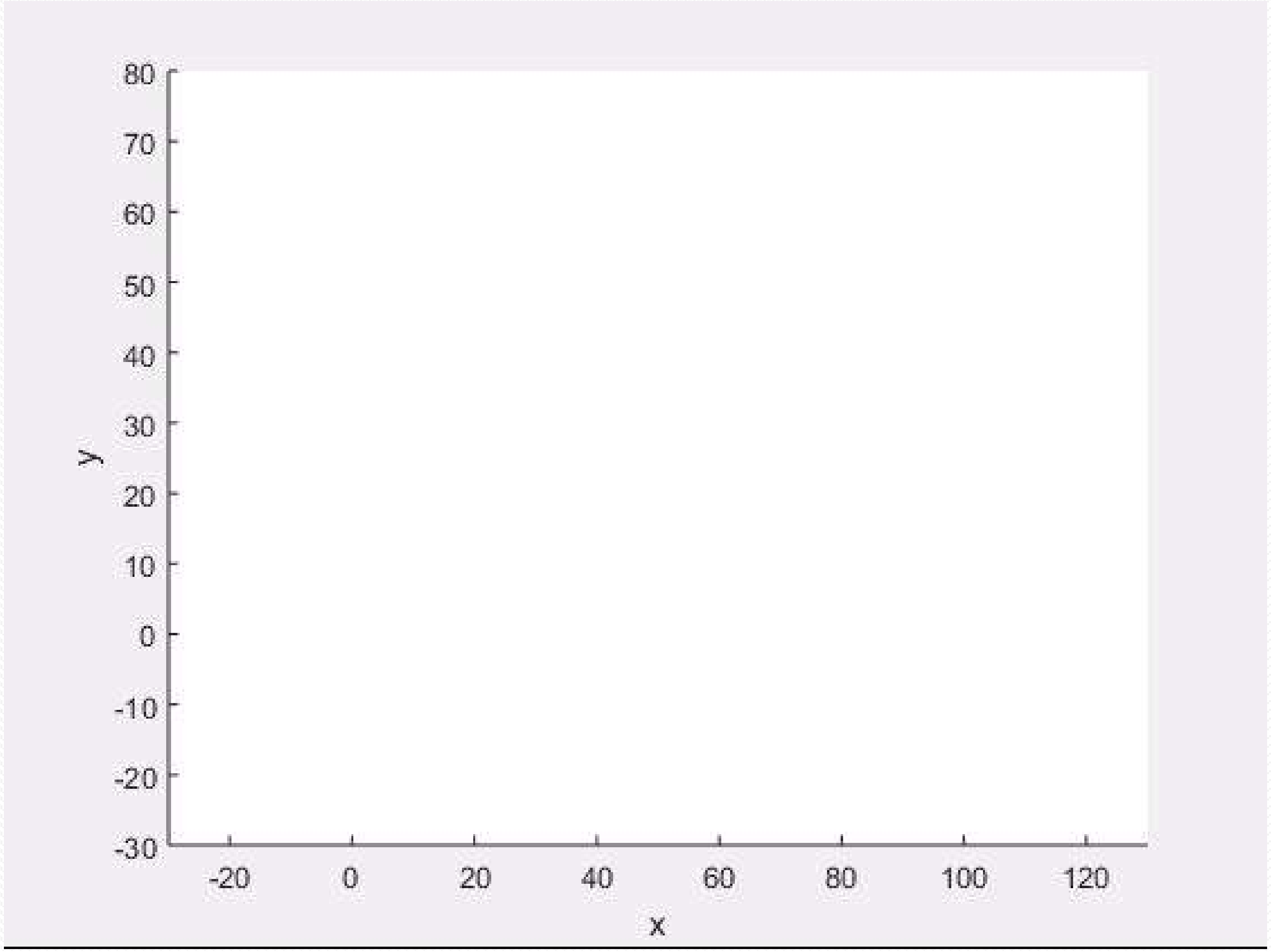


Fig. 11:- Animation of tool path trajectory

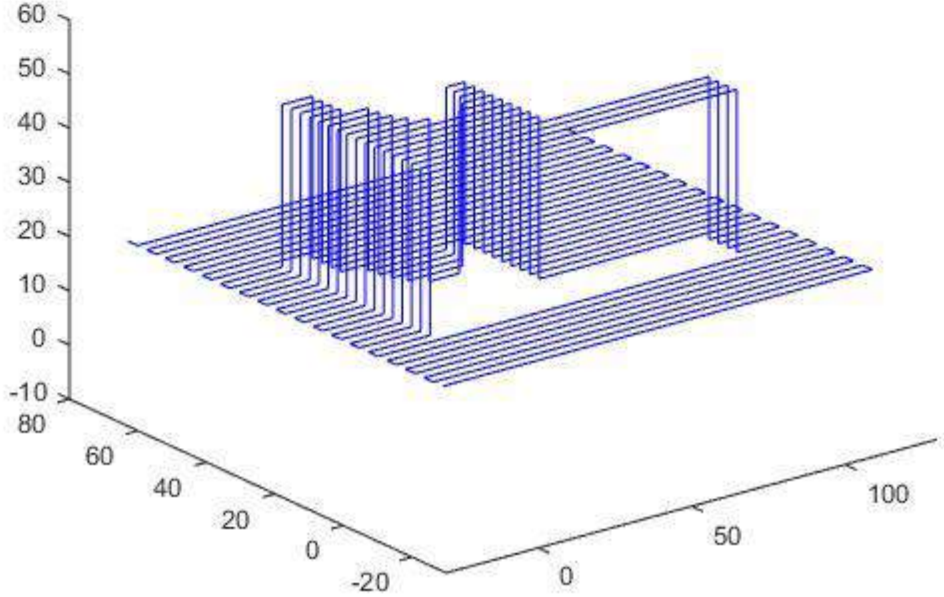


Fig. 10:- 3D representation of tool path lines

FUTURE WORK

- Optimization of an algorithm for slicing of STL file of the 3D object by reducing time-complexity.
- Development of a method to represent the contour formation of each slice with the help of intersection points and normal vector information.

THANK YOU