A NOVEL APPROACH FOR EXTRACTION OF DESIGN FEATURES USING DXF FILES

P. Srikanth, KITS, Warangal
C.S.P Rao, NIT, Warangal
G.RangaJanardhan, JNTU, Kakinada

Abstract

Feature recognition is the key linking element between CAD and CAPP. Different CAD/geometric modeling packages store the design related information in their own databases. Structures of these databases are different from each other. Automatic Feature Recognition (AFR) is the process of extracting such feature data for use in the other stages of product life cycle viz., process planning, CNC code generation and inspection etc. This paper presents different algorithms to extract the design data stored in the form of Data Exchange Format (DXF) files and to store such data in an orderly form. . A software program is developed in 'C++', for extraction of the features (entity) data from the DXF file. The flow chart of the program is given as an appendix. The paper demonstrates the working of the algorithms using a set of examples.

Keywords
CAD/CAPP/CAM, CIM, Feature extraction, Feature recognition

Introduction

The link between Design and manufacturing represents a vast field of research and its growth is crucial to the success of the CAD/CAM industry. While most of the CAD process is generally recognized as an exercise in "Composition", i.e., to make geometric shapes from primitives, CAM processes are characterized by "Decomposition", i.e., extracting sets of surfaces or features to be able to be machined by a set of tools and machining conditions. An intelligent interface between CAD and CAPP systems is imperative because the CAPP systems depend on correct data obtained from CAD systems to perform precise process planning. Feature recognition techniques provide such a connection between CAD and CAPP. However, CAD and CAPP systems form different databases. While CAD databases are usually geometry-based, consisting of geometric primitives such as points, lines and arcs, CAPP systems are feature-based such as faces, cylinders, grooves or pockets [3]. It could be said that the CAPP systems describe in terms of

manufacturing features, whereas CAD describes parts by their solid model or design features. One of the solutions for these problems between CAD and CAM is the automatic feature recognition technique.

Automated feature recognition can best be facilitated by CAD systems capable of generating the product geometry based on features there by making it possible to capture information about tolerance, surface finish and so on. However such CAD systems are not mature yet and their wide usage in different application domains remains to be seen [1]. The design and development of CAM tools has not kept the pace with the growth in CAD techniques. Hence there is enormous scope for research to fill this gap. Automatic feature recognition is the first stage in such effort.

This work is basically designed for the turned components. Owing to the fact that such components are symmetrical about their axis, only the 2-D profile of the upper half of the component has to be designed in any CAD environment and be converted to DXF structure.

LITERATURE REVIEW

Research in the area of feature Data extraction and recognition has emerged from the need to utilize the rapid advancement in CAD. Many different approaches to the problem of feature recognition have emerged which are widely reported in the literature and described by Shah [1] and later Sabin et al.[2,3]. The pioneering work in this area was that of Grayer[4] and Kyprianou [5] , whose research set the scene for much of the subsequent work in this area. Since then several approaches have emerged such as "Alternating sum of volumes (ASV)", developed by Woo [6]. Srinivasakumar et al.[7] have used IGES format for automatic extraction and recognition of part features directly from a CAD model. Pande and Prabhu [8] have presented a paper on the design and implementation of data extraction from DXF and tool selection for rotational components manufactured on Automats. Seker and Aslan[9] have used DXF format for data extraction and

feature recognition for prismatic parts to be machined in milling machines. Yakup Yildiz et al.[10] has developed an automatic feature recognition system for rotational parts using DXF files.

DXF FILE FORMAT

Data Interchange Format (DXF) is a common structure, which is widely used for this purpose. DXF files are standard ASCII text files with a file type of .dxf and specially formatted text. These files can be easily translated to the formats of other CAD systems or submitted to other programs for specialized analysis. The overall organization of a DXF file is as following [11].

1. HEADER section - General information about the drawing is found in this section of the DXF file. Each parameter has a variable name and an associated value.

2. TABLES section - This section contains definitions of named items.

   o Linetype table (LTYPE)

   o Layer table (LAYER)

   o Text Style table (STYLE)

   o View table (VIEW)

   o User Coordinate System table (UCS)

   o Viewport configuration table (VPORT)

   o Dimension Style table (DIMSTYLE)

   o Application Identification table (APPID)

3. BLOCKS section - This section contains Block Definition entities describing the entities that make up each Block in the drawing.

4. ENTITIES section - This section contains the drawing entities, including any Block References.

5. END OF FILE

A DXF file is composed of five groups viz, HEADER, BLOCKS, TABLES, OBJECT and ENTITIES each of which occupies two lines in the DXF file. The first line of a group is a group code, which is a positive nonzero integer, right-justified and blank filled in a three-character field. The second line of the group is the group value, in a format that depends on the type of group specified by the group code. However, all the feature related information is present in the ENTITIES section of the DXF file. This section consists of all the geometric information pertaining to the design features (entities) used in the drawing viz., LINE, POLYLINE, and ARC etc., lines may be parallel, perpendicular, inclined to the axis or it may be curved. The 2D profile shown in the Figure 1. has 15 different features including the axis. Even though it is possible to draw the given profile in different ways in CAD environment, lines and arc commands are used individually to test the algorithm. Figure 2 shows the 3D view of the profile. The ENTITIES section of the DXF file for the given 2D profile is presented in the Table.1. In the actual DXF file all the data (DXF codes and respective values) are in a single column one after the other.

DXF code '0' in the first row of the first column in Table.1 indicates that a new section is started. Name of the section (ENTITIES) is available in the fourth row of the first column. X, Y, and Z coordinate values of different points are available after DXF code 10, 20 and 30 respectively.
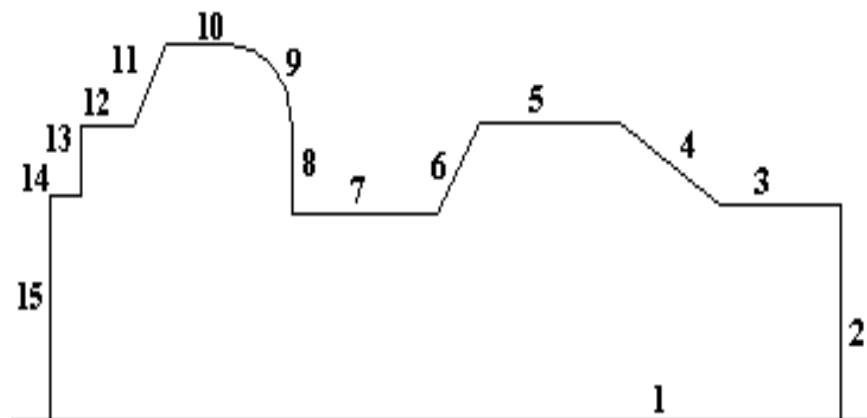
3. DRAWING:

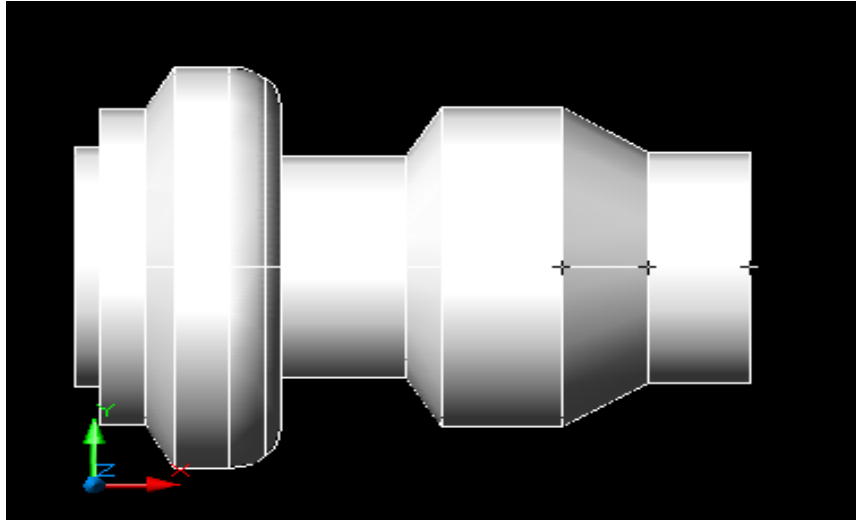**Figure 1: 2D profile of the upper half of the part**

Figure 2: 3D model of the given part

0	0	30	11
SECTION	LINE	0.0	3.671368189755412
2	5	11	21
ENTITIES	26E	8.99640047584171	5.278417857517069
0 (*ENTITY TYPE*)	330	21	31
LINE	1F	4.474337391290418	0.0
5 (*HANDLE*)	100	31	0
26D	AcDbEntity	0.0.	ARC
330	8	. . . .	5
1F	0	10	275
100	100	8.99640047584171	330
AcDbEntity	AcDbLine	20	100
8 (*LAYER NAME*)	10	4.474337391290418	AcDbEntity
0	10.48603797718033	30	8
100	20	0.0	0
AcDbLine	2.387149477465072	11	100
10 (*X Co-ordinate*)	30	7.763596212960692	AcDbCircle
0.19554398309355	0.0	21	10
20 (*Y Co-ordinate*)	11	5.278417857517069	2.917989117519027
2.387149477465072	10.48603797718033	31	20
30 (*Z Co-ordinate*)	21	0.0	5.278417857517069
0.0	4.474337391290418	…..	40 (*radius of Arc*)
11	31	AcDbLine	0.753379072236384
12.90028120333363	0.0	10	100
21	AcDbLine	3.671368189755412	AcDbArc
2.387149477465072	10	20	50 (*Initial angle*)
31	10.48603797718033	4.405905772709047	0.0000000000000

0.0	20	30	51	(*Final angle*)
4.474337391290418	0.0		90.0	

Table 1. **Exerts of DXF file (Entities Section*)**

ALGORITHM FOR DATA EXTRACTION

Step1. Save the AutoCAD drawing as .dxf

Step2. Execute the developed file reading program to find the word "ENTITIES". (This section contains all the geometric information of entities used in the drawing)

Step3. Find the type of entity, by which the part profile is drawn (POLYLINE, LINE and ARC etc.,). Refer to Appendix

Step4. If the entity is POLYLINE, then execute subprogram 1.

Explanation: This subprogram extracts the X and Y coordinates of the vertex points (values below the DXF codes 10 and 20 are the coordinate values of X and Y respectively). Refer to Figure4 in the Appendix. The DXF code 42 indicates that the feature is Arc.

(Else)

Step5. If the entity is LINE, then execute a subprogram 2.

Explanation: This subprogram extracts the X and Y coordinates of the starting and ending points of the line. Values below the DXF codes 10 and 20 are the coordinate values of X and Y of the starting point while the values below the DXF codes 11 and 21 are the values of X and Y of the ending point of the line respectively. In the case study given here we had used the line command, the details of which are shown in the Table 1.As the DXF file runs in very large number of lines, only some exerts of the entities section are given. The profile had been

drawn with random decimal coordinate values. This is done to confirm the ability of the program to read the decimal values and present the output file (Drawout) with limited (4) decimal values as shown in Table 2. For the flowchart refer to Figure5 in the Appendix.

(Else)

Step6. If the entity is ARC, then execute subprogram 3.

Explanation: The values below the DXF codes 10 and 20 represent the coordinate values of the center point of the arc. And the value below the DXF code 40 is the radius of the arc. The values below the Flags 50 and 51 are the starting and ending angles of the arc. The same details for the given profile have been shown in the Table 2. For the flowchart refer to Figure6 in the Appendix.

Step7. Repeat steps 3-6 until it reaches 'ENDSEQ', i.e. the end of the entity section.

RESULTS & DISCUSSION

The program is capable of extracting the details of the entities viz., POLYLINE, LINE and ARC. It saves the details of these entities in an output file (Drawout) as given in the Table 2. The first column of the table represents the type of Entity and in this case we had used only two commands i.e., line and arc. The X co-ordinate values of the initial point are given in column 2 and the corresponding Y co-ordinate values are given in column 3. Column 4 and 5 represents the X and Y coordinate values of final points of the lines. In case of Arc, the co-ordinate values of the centre of the arc are given in column 2 & 3. Value in column 4 represents the radius of the arc. Following it, the starting and ending angles of the arc are provided. Column 6 represents the type of line (Horizontal or Vertical). The logics used to determine the types of lines and their orientation are given in Table 3. The orientation of the lines is made depending on the initial and final coordinates of the corresponding entities.

Entity	x1	y1	x2	y2	Type
line*	0.1955	2.3871	12.9003	2.3871	Hztl line
line	10.4860	2.3871	10.4860	4.4743	Vrtl line
line	10.4860	4.4743	8.9964	4.4743	Hztl line
line	8.9964	4.4743	7.7636	5.2784	Incl line
line	7.7636	5.2784	6.0171	5.2784	Hztl line
line	6.0171	5.2784	5.4692	4.4059	Incl line
line	5.4692	4.4059	3.6714	4.4059	Hztl line
line	3.6714	4.4059	3.6714	5.2784	Vrtl line
arc	2.9180	5.2784	0.753379**		
	Initial Angle: 0.0000				
	End Angle: 90.0000				
line	2.9180	6.0318	2.1304	6.0318	Hztl line
line	2.1304	6.0318	1.7023	5.2613	Incl line
line	1.7023	5.2613	1.0517	5.2613	Hztl line
line	1.0517	5.2613	1.0517	4.5599	Vrtl line
line	1.0517	4.5599	0.6750	4.5599	Hztl line
line	0.6750	4.5599	0.6750	2.3871	Vrtl line

* - Axis line   ** - Radius of the Arc
(V*alues are being limited to 4 decimal places*)

Table 2. Output file (Drawout) showing the type of Entities and their coordinate values for the given profile
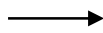
Logic	Line	Direction	Type of Representation
If y1=y2 and x1<x2	Horizontal	⟶	hztl line
If y1=y2 and x1>x2	Horizontal	⟵	hztl line
If y1<y2 and x1=x2	Vertical	↑	vrtl line
If y1>y2 and x1=x2	Vertical	↓	vrtl line
If y1<y2 and x1<x2	Inclined	↘	incl line
If y1>y2 and x1<x2	Inclined	↘	incl line
If y1>y2 and x1>x2	Inclined	↙	incl line
If y1<y2 and x1>x2	Inclined	↖	incl line

Table 3. Different Logics used to determine the line Property

CONCLUSION

An algorithm for the extraction of design feature data from DXF files is demonstrated with an example. The algorithm gives out the feature data even when the profile is drawn with a combination of commands viz., LINE, POLYLINE and ARC. The goal of the research is to develop an automated process planning system for the turned parts.

The output of this program shall be utilized as an input to the next stage of process planning.

The program was developed in 'C' language.

REFERENCES

1. Shah.J.J, 1991, "Assessment of features technology", CAD 23 (5) 331-343.
2. Sabin.M, P. Gibson, H. Ismail, May 1996, "A feature recognition project", 5th IFIP workshop on Geometric Modeling in CAD, London.
3. Sabin.M, P.Gibson, H.S. Ismail, August 25-27,1997, "Interactive programmable feature recognisor", Annals of CIRP 1997, , Hallwag Ltd, Berne,vol. 46.
4. Grayer. A, 1976, "A computer link between design and manufacture", PhD dissertation Cambridge University.
5. Kyprianou.L.K, 1980, "Shape classification in Computer Aided Design", PhD dissertation Cambridge University
6. Woo.T.C, 1982, "Feature extraction by volume decomposition", TR 82-4, Department of Industrial and Operations Engineering, University of Michigan.
7. Srinivasakumar. S., Madurai and Li Lin, 1992, "Ruled based Automatic part feature extraction and recognition from CAD Data", Computers Ind. Engineering, Vol 22, No.1, pp 49-62.
8. Pande, S., S., and Prabhu, B., S., 1990 "An Expert System for Automatic Extraction of Machining Features and Tooling Selection for Automats", Computer-Aided Engineering Journal, pp 99-103.
9. Seker.U, Aslan.E, 1995, "NEU-A feature recognition method for defining machinable segments of a part for jigs and fixture design", International Congress gear Transmissions, 95,pp 157-160, Sofia, Bulgaria.
10. Yakup YILDIZ, Ihsan KORKUT, Ulvi SEKER, 2006, "Development of a Feature Based CAM System for Rotational Parts, G.U. Journal of Science, 19 (1) pp 35-40.
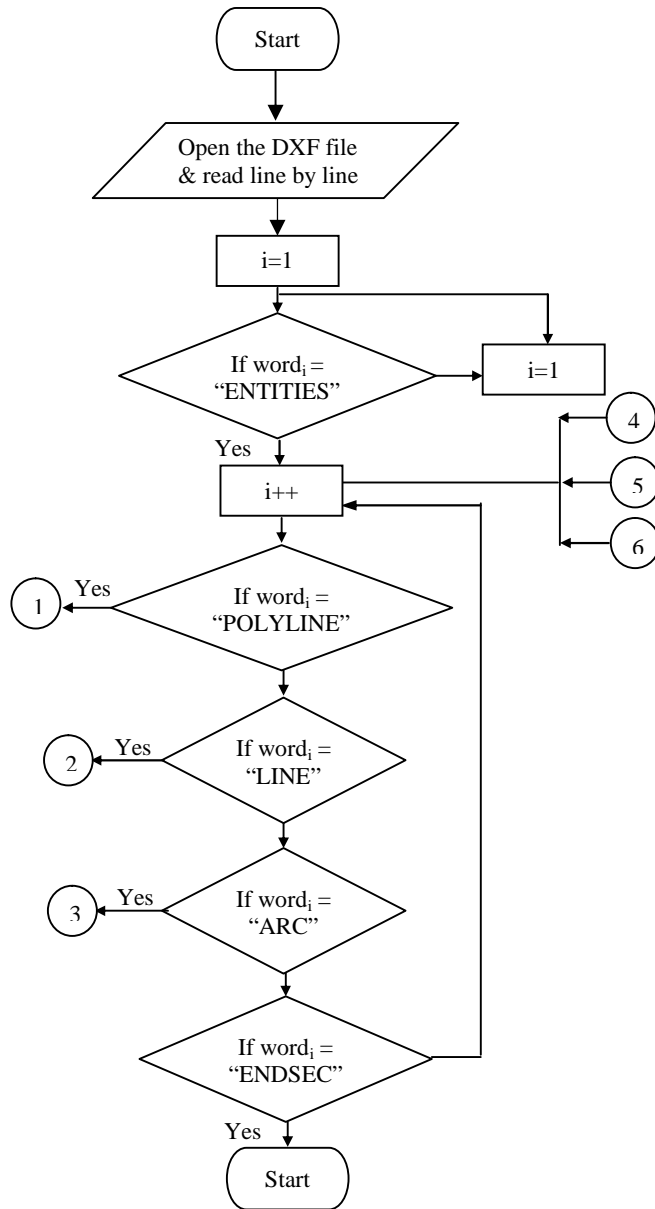11. Online help AutoCAD Release 12 DXF Format, AutoDesk Inc.

APPENDIX

Start

Open the DXF file
& read line by line

i=1

If word$_i$ =
"ENTITIES"

i=1

4

5

6

Yes

i++

If word$_i$ =
"POLYLINE"

Yes → 1

If word$_i$ =
"LINE"

Yes → 2

If word$_i$ =
"ARC"

Yes → 3

If word$_i$ =
"ENDSEC"

Yes

Start

Figure3: Flow chart showing the overall structure of the Extraction Program

1

i++

If word$_i$ = "10"   No

i++

Store as 'X' coordinate in output file

i++

If word$_i$ = "20"   No

i++

Store as 'Y' coordinate in output file

i++

If word$_i$ =
"42"   No

i++

Store the value in to output file
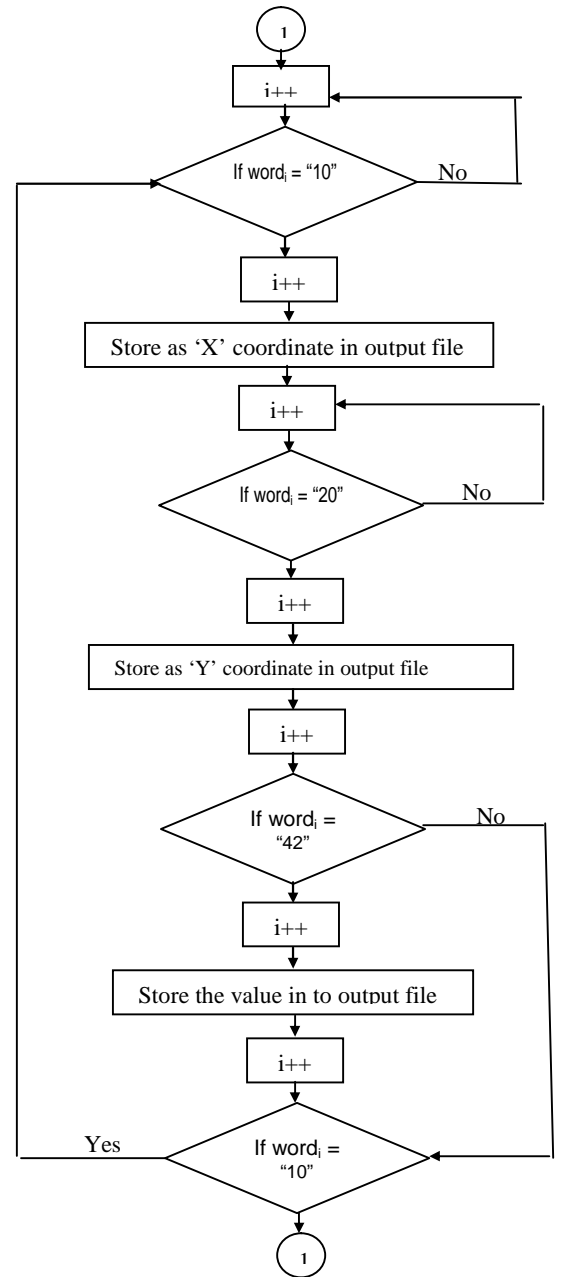
i++

Yes   If word$_i$ =
"10"

1

Figure4: Flow chart for feature extraction of profiles drawn by POLYLINE command
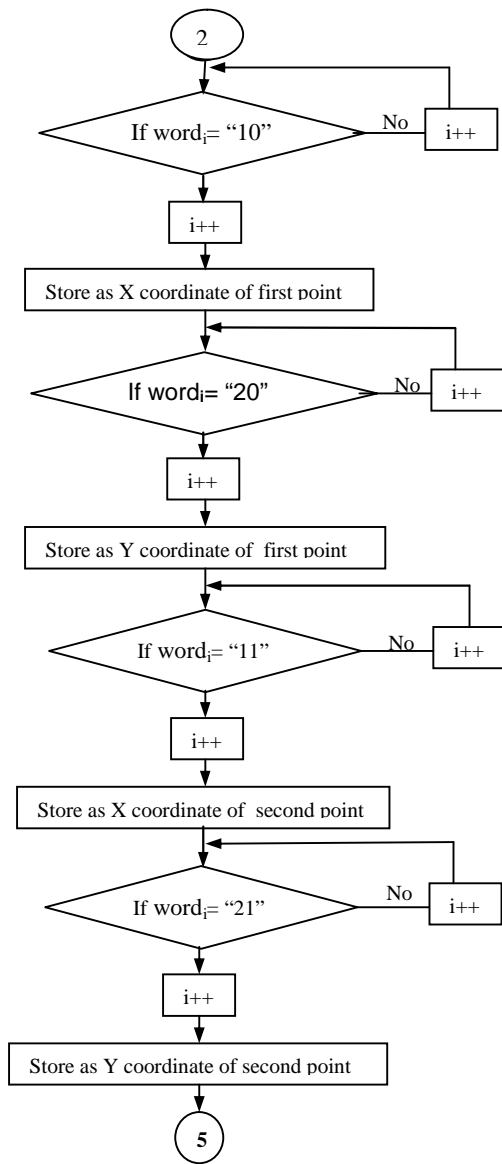
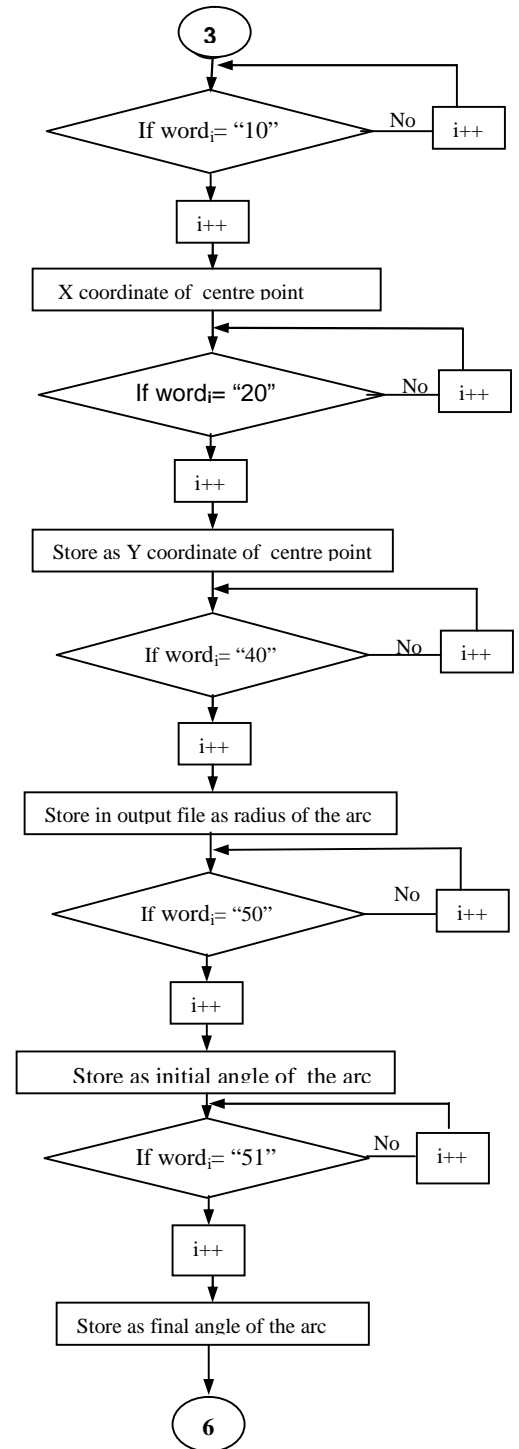**Figure5: Flow chart for feature extraction of profiles drawn by LINE command**

Figure6: Flow chart for feature extraction of profiles drawn by ARC command