Chapter - 2

LITERATURE REVIEW

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LITERATURE REVIEW

Computer aided design (CAD) and computer aided manufacturing (CAM) play a major role in manufacturing industries. CAD and CAM are concerned with the application of computers in the manufacturing of engineering components starting from planning, design, production, quality control to the finished stage. A detailed review of existing literature is presented in the following sections to make a comprehensive overview of the present work.

2.1 REVIEW OF RESEARCH ON GEOMETRIC DATA EXTRACTION

Many researchers studied the concept of extracting geometrical data by considering different CAD models in the standard format like Initial Graphics Exchange Specification (IGES), Data Exchange Format (DXF) and STandard for Exchange of Product (STEP) format. The extraction of geometric features in a design database has received considerable attention since the mid-1970s. Woo [1] proposed a methodology for extracting geometric information from a CSG model for 2½ D work pieces. He also proposed a methodology on "Alternating sum of volumes" in the year 1982. Design and implementation of data extraction from DXF and tool selection for rotational components manufactured on automats was presented by Pande and Prabhu [2]. Kruth et. al [3] presented a method to define and extract user definable manufacturing feature information from wire frame and feature based CAD systems. The authors applied the method with AutoCAD and Unigraphics file formats and incorporated a method to extract geometrical and technological feature information. Zuraini and Habibollah [4] presented the future works of an algorithm to classify features of DXF file and algorithm for mapping the features with machining parameters. The code recognizes geometric entities which assist in identifying the features of the 3D object. The generated features from code classification algorithm give the information of machining parameter through the mapping algorithm.

The mapping algorithm focuses on the dimension of the machine for the milling process which is the length offset, corner radius and depth. The optimization of the machining operations is achieved using the evolutionary technique. Kumar and Saha [5] proposed a methodology to read the STEP neutral file of a solid model and extraction of data from it. They developed software "STEP READER' to read the STEP neutral file automatically as per the requirement of automatic feature recognition. Srikanth et al. [6] presented different algorithms to extract the design data stored in the form of Data Exchange Format (DXF) files and to store data in an orderly form. Mohamad et al. [7] focused on CAD data extraction approach to identify product information. CAD data referred as Computer-Aided Design (CAD) data extracted from the CAD drawing which contained the drawing of product produced by manufacturing. CAD data consists of geometric and non-geometric data. Geometric data contains lines, curves and vertex and non geometric data includes texts, colors and layers. The extracted CAD data is needed to generate the product information, useful to produce the product as depicted in the CAD drawing.

2.2 REVIEW OF RESEARCH ON FEATURE RECOGNITION

Automatic manufacturing feature recognition and feature model conversion have been active research areas for more than two decades. Several Automatic Feature Recognition (AFR) techniques have been developed, such as heuristic, syntactic pattern, rule based, hint based, graph based and neural network. Among the various techniques, the STEP file based Technique has caught the major attention of the author, because of its capability to recognize cylindrical features from axi-symmetrical parts having different features with their dimensions.

Hsu-Pin Wang and Ching-Ann Lin [8] developed two algorithms based on 2-D drawing files. The first algorithm recognizes surface feature of turned parts and then passes to the second algorithm for NC part program generation. Srinivasa kumar et al. [9] used IGES format for automatic extraction and recognition of part features directly from a CAD model. Seker and Aslan [10] used DXF format for data extraction and feature recognition of prismatic parts produced on milling machines. Wang and Wong [11] presented a feature based design system using an object oriented approach with the incorporation of a rule based database to transform the feature and design information into manufacturing instructions and sequence. Sabourin and Villeneuve [12] developed an expert system for CAPP, which takes the feature-based model from CATIA as input and determines the operation sequence and setups for the machining features. Jung and Lee [13] developed an automatic feature recognition system using the IGES data exchange format as input for rotationally symmetric parts. Fuh et al. [14] used a CAD model and an engineering drawing to include geometrical and non-geometrical information to guide feature recognition, so that a workable process plan can be generated considering machining and fixturing requirements. All these works assume that the tool approach direction is known in advance. Further, they can handle only a predefined class of feature interactions.

Yang and Lee [15] presented a geometry setup and operation oriented decomposition based feature modification framework for the generation of alternative process plans. The authors found method is effective with grooved and profile features where tool changes are necessary. The features are decomposed and divided into machining features that can be machined using fewer tools. Ganesan and Devarajan [16] carried out feature recognition from 2D orthographic projections of the component, thus reducing the complexity of the analysis. Gao [17] presented hybrid machining feature recognition system by pulling together the positive capabilities of various approaches to enhance the computational efficiency and capability of the feature recognition system.

Jiang et al. [18] presented a group technology based feature identification and extraction framework in which an expert system with database is used to generate the optimal process plan. Bhandarkar and Nagi [19] developed a standard oriented form feature extraction system that converts lower level geometrical and topological data specified in a STEP file into relevant manufacturing data. Smooth edges to recognize the features containing them are not classified by them. The single level feature taxonomy proposed does not provide any manufacturing related information. Feature intersection and their relationships are not studied. Saad M A S and Khalil A A [20] proposed three modules, namely, structured modeling, feature recognition and feature sequencing for machining rotational parts.

Nagraj and Gurumoorthy [21] described an approach to extract machinable volumes that need to be removed from the stock, from the given part model. The major limitation of direct retrieval approaches is that they are dependent on a specific CA modeler. Saravanan et al. [22] presented Genetic Algorithm (GA) and Simulated Annealing(SA) techniques applied to solve the continuous machining profile problem. Simulated Annealing performs slightly better than Genetic Algorithm. Ong et al. [23] developed a manufacturing feature recognition system from a design by feature model. Their feature recognition processor converts the design features in a CSG tree into manufacturing features by traversing from its root to the highest leaf. They carried out a detailed feature relationship analysis, which is mostly dependent on geometric and placement characteristics of the features. They also developed a manufacturability evaluation module.

Fu et al. [24] proposed an approach to identify design and manufacturing features from a data exchanged part model. Their edge classification also considers smooth edges. The edges in this work are classified as convex, concave, hybrid, convex-tangent and concave-tangent. They proposed multi level feature taxonomy for both design and machining features based on feature geometry and topology entities. The machining features are classified into Inside Form Features (IFF), Outside Form Features (OFF) and Surface Features (SF). Both the form features are further classified into convex and concave for protrusion and depression form features.

Kingsly et al. (25) developed a feature based design system, which can be applied in the concept of manufacturing stages of the machining process. The developed system is built on existing CAD, programming and spreadsheet software tools. Amaitik and Kilic (26) developed a system that creates the features and attributes and generates the feature model in STEP format. Singh and Jebaraj [27] proposed a feature based design for process planning where the optimal process plan was generated from the part model in a commercially available CAD format processed by the knowledge base (virtual factory environment). The proposed model is also capable of converting the plan into NC codes. Yakup Yildiz et al. [28] developed an automatic feature recognition system for rotational parts using DXF files.

Verma and Sunil [29] developed a hint based machining feature recognition system for 2.5D parts with arbitrary feature interactions. A pre-processor is used to screen out invalid 2.5 D parts automatically and calculate the possible machining directions. Nagarajan and Venkata Reddy [30] developed a STEP based platform independent system for design and manufacturing feature recognition. The system can recognize both design and manufacturing features from the lower level geometry and topology available in the STEP file. The various techniques used by researchers for rotational and prismatic parts of 2D, 2.5D and 3D are presented in Table 2.1.

Table 2.1: Various techniques used by researchers

year	Name	Technique	Rep-type		Standard type			Dimension type			Feature	
			CSG	B-REP	DXF	IGES	STEP	2D	2.5D	3D	R	P
2000	Bhandarkar[31]	Heuristic		√			√			√		√
2001	B.S.Prabhu[32]	Heuristic			√	√				√		√
2004	S.C.Liu [33]	Heuristic		√		√				√	√	
2006	A.Nasr [34]	Heuristic	√	√		√				√		√
1999	B.S.Prabhu [35]	Syntactic			√	√				√		√
2008	A.Arivazhagam [36]	Syntactic		√			√			√		√
2001	Nafis Ahmad [37]	Rule		√	√					√	√	
2005	C.F.Tan[38]	Rule		√			√			√		√
2005	H.C.W.lau[39]	Rule		√			√			√		√
2006	Yildiz[40]	Rule			√			√			√	
2007	Risal Abu[41]	Rule		√						√		√
2008	T. Yifei [42]	Rule					√			√	√	
2009	M.S.Shanmugam[43]	Rule		√			√			√		
2005	S.S.Dimov [44]	Hint&Rule		√			√			√		√
2001	J.H.Han[45]	Hint							√			
2003	M.Kang[46]	Hint		√			√	√	√	√		√
2008	A.K.Verma [47]	Hint		√					√			
1987	K.S.fu[48]	Graph	√									
1990	M.Marefat[49]	Graph		√						√		√
2002	M.M.Koura[50]	Graph		√						√	√	√
2002	A.D.Mc.cormack [51]	Graph					√			√		√
2007	Li Shiqiao [52]	Graph									√	
1997	C.Zhang[53]	Graph		√						√		√
2009	Zhang[54]	GHR		√						√	√	√
2009	V.B. Sunil [55]	N.N		√					√			√
2010	X.Guan[56]	N.N		√			√			√		√
2005	Rakesh Ranjan[57]	RFT		√				√				√

Note: N.N- Neural Network; G.H.R-Graph, Hint and Rule ; RFT-Ray Firing Technique

2.3 CRITICAL OBSERVATIONS

The following are the observations from the literature:

1. Many of the researchers extracted geometrical data from the standard formats like IGES, DXF, STEP codes etc. There is no literature on how to extract geometrical data from STEP file, particularly for rotational components.

2. Literature on cylindrical holes in prismatic parts is available, whereas literature to recognize cylindrical hole in a cylinder perpendicular and inclined to the axis is not available.

4. Prismatic parts are considered by most of the researchers. There is no literature available for the recognition of curved features in rotational components.

5. No author has considered the cross hole feature recognition which may be through or blind in the positions such as perpendicular or inclined to the axis.

6. It is observed from the literature that features like slot, keyway and elliptical in rotational components are not recognized.

7. There is limited literature reporting the machining of an axi-symmetrical component from STEP file without human intervention in the intermediate stages.

2.4 OBJECTIVE AND SCOPE OF THE STUDY

The objective of the present research work is identified based on the review of the existing literature and critical observations as mentioned in section 2.3. The main objective of the present research is to develop software to extract information from the STEP file to determine turning features existing on rotational components. It is an attempt to automate feature recognition from “STEP to feature” (STF), which in turn reduces time spent on feature recognition, there by improving productivity and minimizing the cost of manufacturing.

Towards this goal, the scope of the research work is outlined as follows:

1. Development of a program to extract all the salient point coordinates of a part from the STEP file and stored in arrays and displayed in tables.
2. Development of a program to recognize manufacturing features from the extracted data.