RECOGNITION OF INTERACTIVE FEATURE FOR AUTOMOTIVE PARTS USING SYSTEMATIC PATTERN METHOD

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ABSTRACT

The integration of automated manufacturing resources for supporting the design and manufacturing of industrial parts and products. The required process designs are too difficult to produce due to the lack of the required data interface for CAD / CAM and CAPP systems. In production processes from established drawings, the extraction of features and recognition play an important role. The boundary representative information (B-rep) extracted from the STEP (STandard for Exchanging Product Model Data) file for the identification of the design features obtain. This paper presents feature recognition system is discussed to provide the solution for extraction of geometric features from solid model. The product data represented in STEP AP-214 neutral file format and a systematic pattern recognition approach is used to recognize simple primitive features of the automotive part.

KEYWORDS: STEP, CAD, CAPP, CAM, Feature Recognition

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1. INTRODUCTION

Computer - aided design (CAD) and computer aided manufacturing (CAM) integration have improved output efficiency in today's manufacturing industries and will increase productivity through the use of generative CAPP with CAD / CAM. In order to achieve generative process planning, automatic feature identification (AFR), is required. AFR approaches provide the capacity to identify geometrical and high - level characteristics [1,2,3] and methods such as graph dependent, rule-based, descriptive, volume decompose approaches have so far been used to identify features from CAD models [4]. Scientists also use other techniques to recognize features such as edge boundary grouping, slicing process, smart methods for feature recognition, and ontology.

Product features play a vital role in CAD, CAPP and CAM integration because they provide high-level information that can effectively connect design to manufacturing [5, 6]. Different feature recognition methods have been developed and introduced. Machining feature recognition has been intensively studied during the past few decades.

Exhaustive analyses were carried out in [7, 10] the current recognition methods. The key methods can be classified into five groups according to the existing literature: graph-based approaches, hint-based approaches, hybrid approaches, volumetric decomposition approaches [11], and artificial neural network-based approaches [12]. For a product a function is known as a local component of a product that can be directly linked to the production process, as it indicates the amount that can be eliminated by one or a number of operations. Once a certain component is defined by its characteristics, production methods can be easily identified as a set of work, coupled

with production materials such as machine tools, cutting equipment, fittings and machining specifications. It is therefore possible, in order to determine the machining preparation for a given part, to merge manufacturing information and data with known features. Step, slot, pocket and hole are regarded as major features of automotive part which represent the machinable volumes. These features are also called as primitive features since each feature possess a set of geometrical properties. The primitive features may be further categorized as 'through' and 'blind features' The process describes the basic logic and methodologies for the recognition of primitive features. The logic and basic methodology have been highlighted in the following sections by considering range of features with simple as well as complex structures.

In the process of syntactic pattern recognition, a component model is rendered utilizing semantic primitives written in any descriptive language. Syntactic pattern recognition involves the interpretation of primitives, as well as automatic concept model translation in a component descriptive appropriate for syntax analysis (string). This method was applied for 2D type recognition more frequently and more effectively [13]. This was built in prisms, in the case of syntactic pattern detection implementation not so commonly done in practice. (2D) for each of border plans of a parallel piped. The first step was to be taken in 3D feature recognition, which had previously to be transformed into a 2D component model.

This framework provides recognition with orthogonal boundary faces of multiple shape features hole, step, slot, and protrusions. Hole is a fundamental feature, and all other features are extracted from it: steps are holes without two faces, slots are holes without one face, and protrusions are viewed as a mixture of slot and phase creation. By addition, graphs are converted into strings of rudimentary form, utilizing Figure 1 outlined technique and then strings in an information base suit the sequence.

Figure 1: Directions Used To Identify the Primitive Features of Part.

2. METHODOLOGY FOR EXTRACTION OF DATA FROM STEP FILE

The first and most critical role in a CAPP program is to schedule specific tasks in consideration of machining functionality from a CAD model. This section discusses the various techniques utilized by specific feature recognition strategies and neutral formats in order to recognize output characteristics. The writers use each of these techniques: heuristic, syntactic, rule-based, alert-based, mixture of clue and law, graph-based and neural network. Much of the researchers based on understanding features of vehicle components. Furthermore, it is found that lesser focus is being given to features for Stage automotive components. The key objective of this article is to understand features for Phase file automotive components.

A STEP data file is a text file with geometric part details, including the boundary description details as shown in figure 2, such as shells and facets, vertices, geometric surface data, e.g. planes, triangles, cones, tores; geometric curve data such as arcs, loops, ellipses and curves in the B-spline. The STEP search file begins with a CLOSED_SHELL string and

ends with a cartesian point that suggests geometry coordination. The hierarchy is used for removing multiple strings from STEP files, such as the loop string, the face outer loop, face bound, etc. and entities (# number). Limited STEP file lines needed to clarify the feature recognition technique. The next stage is the recognition of compatibility after removing geometric details from the STEP file. Those laws are used in the recognition of a feature, the technique of through slot and through Step recognition is part of this study.

Figure 2: Common Entities of STEP File

3. RECOGNITION OF INTERACTIVE FEATURES OF PART MODEL

The feature recognition processes described in previous chapters focus on the recognition strategies for primitive features. Further, from these discussions, it is clear that each primitive feature possesses certain basic characteristics defined through their structure in terms of the surfaces forming it. The basic characteristics / geometric properties of primitive features play an important role in their recognition since feature recognition involves reasoning about their presence through their geometrical properties.

When one primitive feature interacts with another primitive feature then either one feature or both may not maintain their basic characteristics and together result in a complex feature. This significant factor must be considered while recognizing interacting features. Also, two interactive features always share a common volume and therefore consideration of the interaction between features together is very much necessary for carrying out the machining planning and setup planning activities for the given part. In the present chapter, the process of recognizing interacting features have been described, by considering the typical cases of interaction found in prismatic parts. The following are the three cases of interaction between primitive features.

4. DESCRIPTION OF FEATURE

Stepped Hole: The Stepped Hole feature is an internal or isolated feature consisting of more than one hole with different diameters and placed one hole into the other forming Stepped or multiple holes as shown in Fig.3. In this case, the Stepped Hole considered has two holes, the top hole is having bigger diameter than others and it's one end opens on the top face of the part model by intersecting with it. The intersection forms a circular edge on the face. The other end of the hole is closed. The second hole starts at the closed end of the first hole by intersecting with the face and forming a circular edge on the face. The other end of the second hole is closed. The other end of the hole opens on the bottom face of the part model by intersecting with it. This intersection again forms a circular edge in the bottom face. This circular edge is connected by respective cylindrical surfaces. In STEP file the hole feature is represented by circular edges and cylindrical surface and these are used as hints for recognizing hole feature.

Figure 3: Part Model Showing, (a) Stepped Hole Feature, (b) Sectional View of Part Model.

5. FEATURE RECOGNITION

The interactive feature of the part model, hole in a hole or stepped hole is recognized by interpreting data from part database shown in Table 6. A procedure is developed to recognize the features by using the data stored in the database. As mentioned earlier the records in the database are grouped according to Advanced Face of the part model. For explanation records related to first Advanced Face #227 is considered. The data from the database table are read record by record and the data of each field is interpreted, null values of fields are neglected which are shown in the table as blanks. After reading the first record the field data found are ADF id #227, the details of this Advanced Face will be found like its Face Bound, Plane, several face bounding edges in Edge Loop, type of geometric entity, geometric entity coordinates, its direction, dimension and normal vector. The next field data found is an id for FACE BOUND (FB) which is #196, this indicates that the data followed are related to the face bound edges of the advanced face. The data of field PL is null. The next fields in the record are EL and ELI; the data are #176 and 1 respectively. The field data ELI shows the number of edges present in the EL is 1 and 4, means the Advanced Face is bounded by four edges. The next field GEID has data #168, 169, #24, #25 #26, #27, #28, and #29 which is the id of the type of geometric entity stored in the next field GE with value "Circle" and "Line", the fields CX, CY and CZ are coordinates of GE Circle which are (16.5, 7.5, 6). The next fields X1, Y1, Z1 and X2, Y2, Z2 store starting and ending coordinates of GE Line, which are (16.5,3.5,6) and (3.5,6,8) respectively. The next fields LL and LDI give the length of the Line and its direction which are 8 and -X respectively. The field SC stores code or character assigned to GE according to syntactic pattern and has value C. The last field in the record is FP its data is null. The next records belong to Line entity and have similar type field values in the same format as explained in the previous record. All these lines are the bounding edges of the AF #227, they are reoriented by referring to the Boolean Flags of the ORIENTED_EDGE entity of STEP file, to make convenient to apply the syntactic pattern and to identify the shapes of the plane.

The last record in the ADF #227 belongs to PLANE entity data, the starting fields ADF, and FB have null values, whereas the field PL has id #216, the next fields EL, ELI and GEID values are null. The field GE has the value "Plane", indicating it is a planar surface. The fields CX, CY and CZ have null values. The next fields in the record are X1, Y1 and Z1 store coordinate of a vertex point through which the plane passes, this point is named as Plane Position Value (PPV) and has values (25, 15, and 6). The next fields X2, Y2, Z2, LL and LDI has null values. The field SC, particularly in this record, all the syntactic codes assigned to geometric entities in previous records will be concatenated and made one string to represent the entire plane and the field data becomes "CACBCB". The last field FP shows the direction of the normal vector to the ADF, which is Z. This record is the last record of the AF #227. Considering the above discussion, the

summary of the AF #227 can be written as, it is a plane of perfect quadrilateral shape bounded by four edges (CBCB), with normal vector in the direction of Z, the plane is parallel to XY plane and passes through PPV (25,15,6). The face is having an internal feature edge which is circular giving a hint for presence of through or blind slot feature. This internal feature is because of FACE_BOUND entity, which is a potential indicator of an internal feature.

Similarly, the other records in the database which belongs to other Advanced Face will be interpreted in the same manner as explained above. After processing all the Advanced Face from the database, the planes #228, #229, #230 and #231 are Perfect Quadrilateral Face because all these planes are having syntactic pattern refer. This can be used as a hint to know whether the Advanced Face contains external feature or not. These Advanced Faces are also not having any internal features because of the absence of FACE_BOUND entity of respected Advanced Face. The Advanced Face #229, #234, #235, are connected with the features. The Advanced Face #232, is Perfect Quadrilateral face but are having internal feature edges which are circular, these edges will be verified with Advanced Face #233 and #236 which are a cylindrical surface for the existence of a holes. A cylindrical surface in a STEP file is a potential indicator of Hole feature.

6. PROCEDURE TO RECOGNIZE STEPPED HOLE

Step 1: Identify the ADF, which is cylindrical surface and record its id, radius, center point coordinate and normal vector (FP) of end circular edges of a cylindrical surface from the database.

Table 1: ADF Having Cylindrical Surface

AF	(X1, Y1, Z1)	Rad	FP
#233	12.5, 1.5, 3	2.5	X
	12.5, 0, 3	2.5	X

Step 2: Identify the ADF having end circular edges of the cylindrical surface found in step-1. The top edge found on face #75 and the bottom edge found on #82, the recorded data are, Observe the above data, AF #232 face contains the top edge of the cylindrical surface whereas the AF #234 which is circular in shape forms the bottom of the cylindrical surface. This circular face has another circular edge (additional) edge with radius 1.5, this indicates there is another hole at the bottom face of the cylinder. The above data shows, there is a blind hole on face #232 with radius 1.5 and another circular edge (hole) at the bottom of the blind hole, this is because of FB present in the face #234, if FB was absent then there won't be any feature at the bottom face of the blind hole and it will be a simple blind hole, further processing can be stopped for a stepped hole.

Table 2: ADF Having Circular Edge Cylindrical Surface

AF	(X1, Y1, Z1)	Rad	FP
#232	12.5, 0, 3	3	Y
#234	12.5, 1.5, 3	3	Y

Step 3: Identify the ADF which is a cylindrical surface with one of its circular edge is on face #234 and radius equal to 1.5. The ADF found which is cylindrical is #236 and its data are,

Table 3: ADF Having Circular Edge Cylindrical Surface with One of Its Edge Is On Face

AF	(X1, Y1, Z1)	Rad	FP
#236	12.5, 1.5, 3	1.5	Y
	12.5, 3, 3	1.5	X

Step 4: Identify the face on which the bottom circular edge of the cylindrical surface lies. The ADF found is #234 which is circular and the data are,

Table 4 shows, the bottom circular edge of the cylinder lies in face #234, similar to Step-2, this face also contains an additional circular edge with radius 2.5 mm giving hint for another hole. In the absence of this edge, the hole will be stepped and further processing can be stopped.

Table 4: ADF Having Circular Edge Cylindrical Surface

AF	(X1, Y1, Z1)	Rad	FP
#233	12.5, 1.5, 3	2.5	X
	12.5, 0, 3	2.5	X

Step 5: Identify the ADF which contains the bottom edge of the cylindrical surface found in step-1.5 mm with the presence of FB and Y coordinate equal to 0. The face identified is #235, which is the bottom face of the part model and the recorded data are,

Table 5 shows the cylindrical surface found in step-5 has opened its bottom edge in face #235, which is the bottom face of the part model. Further processing is stopped. With the above procedure and data found we can conclude that there is a stepped hole present in the part model having two steps, the first step is between coordinates (12.5,0,3)–(12.5,3), the second step between (12.5,1.5,3)–(12.5,3,3) respectively. The location of the stepped hole feature for origin is (12.5, 0, 3) which can be considered as the key point of the feature which helps in machining. The above procedure is implemented in the software modules with repetitive steps in loops.

Table 5: ADF Having Cylindrical Surface

AF	(X1, Y1, Z1)	Rad	FP
#235	12.5, 1.5, 3	2.5	X

Figure 4: (A) Syntactic Pattern Grammar, (B) Pattern for Perfect Quadrilateral Face, (C) A Pattern For Step Feature.

Figure 5: Example Part Model Having Stepped Hole.

7. DATABASE TABLE

Table 6: Database Table of Interactive Feature Stepped Hole

The total number of planes= 11											The width of the model (Y) = 15										
All dimensions are in mm																					
ADF	FB	EL	ELI	PL	GEID	GE	Rad	CX	CY	CZ	X1	Y1	Z1	X2	Y2	Z2	LL	LDI	SC	FP	
#227	#196	#176	1		#168	Circle	4	16.5	7.5	6											
			1		#24	Line					16.5	3.5	6	8.5	3.5	6	8	-X	C		
			1		#169	Circle	4	8.5	7.5	6										-Z	
			1		#25	Line					8.5	11.5	6	16.5	11.5	6	8	X	A		
	#197	#177	4		#26	Line					25	0	6	0	0	6	25	-X	C		
					#27	Line					25	15	6	25	0	6	15	-Y	B		
					#28	Line					25	15	6	0	15	6	25	-X	C		
					#29	Line					0	15	6	0	0	6	15	-Y	B		
				#216		Plane					25	15	6					Z	CACBCB	Z	
#228	#198	#178	4		#30	Line					0	0	6	0	0	0	6	-Z	B		
					#29	Line					0	15	6	0	0	6	15	-Y	A		
					#31	Line					0	15	6	0	15	0	6	-Y	B		
					#32	Line					0	15	0	0	0	0	15	-Y	A		
				#217		Plane					0	15	6						BABA	Z	
#229	#199	#179	4		#33	Line					0	0	0	25	0	0	25	X	A		
					#32	Line					0	15	0	0	0	0	15	-Y	B		
					#34	Line					0	15	0	25	15	0	25	X	A		
					#35	Line					25	15	0	25	0	0	15	-Y	B		
				#218		Plane					25	15	0						ABAB	-X	
#230	#200	#180	4		#36	Line					25	0	0	25	0	6	6	Z	D		
					#35	Line					25	15	0	25	0	0	15	-Y	B		
					#37	Line					25	15	0	25	15	6	6	Z	D		
					#27	Line					25	15	6	25	0	6	15	-Y	B		
				#219		Plane					25	15	0						DBDB	-Z	
ADF	FB	EL	ELI	PL	GEID	GE	Rad	CX	CY	CZ	X1	Y1	Z1	X2	Y2	Z2	LL	LDI	SC	FP	
#231	#201	#181	4		#28	Line					25	15	6	0	15	6	25	-X	C		
					#37	Line					25	15	0	25	15	6	6	Z	D		
					#34	Line					0	15	0	25	15	0	25	X	A		
					#31	Line					0	15	6	0	15	0	6	-Z	B		
				#220		Plane					0	15	0						CDAB	-Z	
#232	#202	#182	1		#170	Circle	2.5	12.5	0	3										Y	
		#203	4		#26	Line					25	0	6	0	0	6	25	-X	C		
					#30	Line					0	0	6	0	0	0	6	-Z	B		
					#33	Line					0	0	0	25	0	0	25	X	A		
					#36	Line					25	0	0	25	0	6	6	Z	D		
				#221		Plane					0	0	0						CBAD	-Y	
#233	#204	#184	1		#171	Circle	2.5	12.5	1.5	3										X	
	#205	#185	1		#170	Circle	2.5	12.5	0	3										X	
					#20	CS	2.5	12.5	1.5	3										-Y	
#234	#206	#186	1		#172	Circle	1.5	12.5	1.5	3										X	
	#207	#187	1		#171	Circle	2.5	12.5	1.5	3										X	
				#222		Plane					12.5	1.5	3							Y	
#235	#208	#188	1		#173	Circle	1.5	12.5	3	3										Y	
				#223		Plane					12.5	3	3							Y	
#236	#209	#189	1		#172	Circle	1.5	12.5	1.5	3										Y	
					#173	Circle	1.5	12.5	3	3										X	
					#21	CS	1.5	12.5	3	3										-Y	
#237	#211	#191	4		#24	Line					16.5	3.5	6	8.5	3.5	6	8	-X	C		
					#38	Line					16.5	3.5	3	16.5	3.5	6	3	Z	D		
					#39	Line					16.5	3.5	3	8.5	3.5	3	8	-X	C		
					#40	Line					8.5	3.5	3	8.5	3.5	6		Z	D		
				#224		Plane					12.5	3.5	3						CDGD	Y	
ADF	FB	EL	ELI	PL	GEID	GE	Rad	CX	CY	CZ	X1	Y1	Z1	X2	Y2	Z2	LL	LDI	SC	FP	

#238	#212	#192	1		#169	Circle	4	8.5	7.5	6										-Z
			1		#40	Line					8.5	3.5	3	8.5	3.5	6		Z	D	
			1		#174	Circle	4	8.5	11.5	3										X
			1		#41	Line					8.5	11.5	3	8.5	11.5	6		Z	D	
					#22	CS					8.5	7.5	3							Z
#239	#213	#193	4		#25	Line					8.5	11.5	6	16.5	11.5	6		X	A	
					#41	Line					8.5	11.5	3	8.5	11.5	6		Z	D	
					#42	Line					8.5	11.5	3	16.5	11.5	3		Z	A	
					#43	Line					16.5	11.5	3	16.5	11.5	6		-X	D	
					#225	Plane					12.5	11.5	3					ADAD	-Y	
#240	#214	#194	1		#168	Circle	4	16.5	7.5	6										-Z
			1		#43	Line					16.5	11.5	3	16.5	11.5	6		-X	D	
			1		#175	Circle	4	16.5	7.5	3										-Z
			1		#38	Line					16.5	3.5	3	16.5	3.5	6		Z	D	
					#23	CS	4	16.5	3.5	3										Z
#241	#215	#195	1		#175	Circle	4	16.5	7.5	3										-Z
			1		#42	Line					8.5	11.5	3	16.5	11.5	3		Z	A	
			1		#174	Circle	4	8.5	7.5	3										-Z
			1		#39	Line					16.5	3.5	3	8.5	3.5	3		-X	C	
					#226	Plane					8.5	7.5	3							-Z

8. RECOGNIZED INTERACTIVE FEATURE

Table 7: Features Recognized for the Above Part

Feature	Sections	Particulars	Dimensions
Stepped Hole	C1	Radius	3
		Height	1.5
		CARTESIAN POINT FOR CENTER HOLE 1	(12.5,0,3)
	C2	Radius	1.5
		Height	1.5
		CARTESIAN POINT FOR HOLE 2	(12.5,1.5,3)

9. CONCLUSIONS

The algorithm developed recognizes interacting features recognized as in the case of other research approaches. The uniqueness of this study is that the regular form classification shows enhanced volumetric sub - types and the algorithm can detect features, and generate MRV for each internal part of a different feature. This new approach recognizes the severe faces and features and is used to classify the feature type with the recognized faces. The developed algorithm recognizes all features successfully and generates material deletion volume for the object faces. For the further production of automotive components, the identification of contact and volumetric compound features will be useful.

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