

## Feature Recognition System for Rotational Features

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**Abstract:** This study presents the development of a knowledge-based features recognition system for mechanical parts. The main aim of the research was to concentrate on recognition of rotational features, namely, blind hole, through hole and slanting hole to be used in automatic process planning system. The rule-based technique was applied to recognize rotational features. The recognition criteria were based upon geometrical data from Standard for Exchange of Product data file (STEP) of Computer-aided Design (CAD) system. The system consists of several modules, namely, pre-processing module, inference engine module and user interface module. The developed system succeeds the design activities in manufacturing industries.

**Key words:** Rotational feature, computer-aided design, standard for exchange of product data file, interface module, engine module

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### INTRODUCTION

In the modern world, communication is an important foundation for industry. There are many improvements in the technology that able to make our lives easier and better. The computer systems that used in the industry such as computer-aided manufacturing, computer-aided design and computer-aided process planning are to create an 'island of automation' for effective communication purpose. Each system links together for data exchange without taking into account of different data format. The integration of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) is the important aspects for automation system. The CAD/CAM integration leads to Computer Integrated Manufacturing (CIM) where this is a primary system in realizing the development of agile manufacturing, concurrent engineering, information technology and production processes (Lau and Jiang, 1998).

Feature is one of the important elements in the CAD/CAM system. It is because the feature technology is available in the major CAD/CAM software and feature recognition husks. The CAD drawing is

embedded with the feature by the design by features approach or feature recognition approach (Owodunni and Hinduja, 2002).

For the CAD/CAM integration, the basic parts are the feature and feature-based representation. In general, the feature can be viewed as higher-level entities that integrate the information between design and manufacturing. For example, the topological and geometrical information consists in CAD; feature can be used to represent how the part can be manufactured. The part representation in CAD models is in the form of basic geometry and topology that is not suitable to be used in process planning. The feature recognition is bridging the gap between low-level geometrical entities of product design representation within a CAD databases to facilitate process planning and manufacturing activities. In addition, feature recognition is a step to reduce the lead time between design and manufacturing. A feature is classified as characteristic of the element which represents higher semantic meaning to particular application such as manufacturing, engineering, design and assembly (Bhandarkar and Nagi, 2000). In brief, a feature is a parametric shape associated with attributes

such as intrinsic geometric parameters (length, width and depth), position and orientation, geometric tolerances, material properties and reference to other features. Feature also provides access to related production process and resource models. Thus, features have a higher level semantically than the primitive elements used in ordinary CAD systems (Mantyla *et al.*, 1996). In this study, the knowledge-based feature recognition system that developed to recognize the rotational feature that based on STEP file is described.

### ARCHITECTURE OF KNOWLEDGE-BASED FEATURE RECOGNITION SYSTEM

The knowledge-based feature recognition system used Kappa-PC expert system shell to recognize feature of mechanical parts. The basic components of the proposed system include: the knowledge-base, the inference engine and the user interface. Figure 1 shows the general configuration of the proposed system.

The system consists a number of major steps, namely import of STEP file from CAD/CAM system, geometrical data extraction of STEP file, program tree structure and rules development, development of user interface for the system, program testing and verifying.

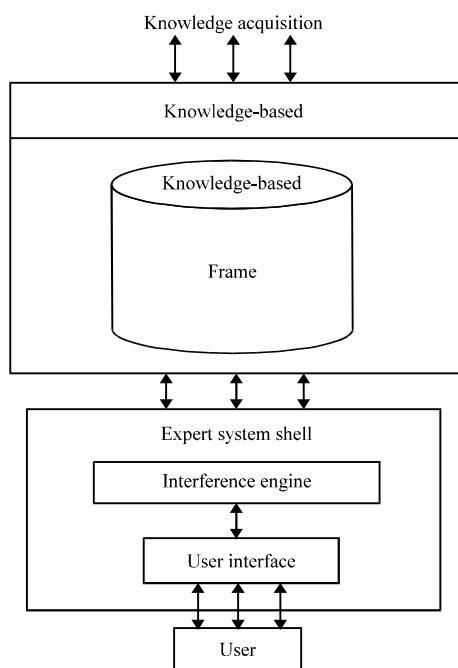


Fig. 1: Architecture of the proposed system

The flow chart for the developed system is illustrated in Fig. 2. The feature recognition algorithm was developed based on the geometrical data from STEP file of UniGraphics CAD/CAM system. STEP or ISO 10303 is an international standard that represent the product data model that is able to interpret and exchange within CAD system. STEP is a common standard that ensures the product data can be communicated electronically across different platforms, such as CAD, CAM and CAE. Part of STEP file for blind hole is shown in Table 1.

All information regarding the feature specification was sent to knowledge base. The inference engine was used to scan the knowledge base by expert system shell by applying "IF-THEN rules" to match the appropriate solutions to the problem. The inference engine interacts with the knowledge base in forward reasoning mechanism to give the best possible solution. Figure 3 shows the rule editor window. The user interface of the developed knowledge-based feature recognition system is shown in Fig. 4.

Table 1: Part of STEP file for blind hole

|   |
|---|
| #23 = CARTESIAN_POINT ('(,1.,1.,2.);        |
| #24 = DIRECTION ('(,0.,0.,-1.);             |
| #25 = DIRECTION ('(-1.,0.,0.);              |
| #26 = AXIS2_PLACEMENT_3D (',#23, #24, #25); |
| #27 = CIRCLE (',#26, 0.5);                  |
| #28 = EDGE_CURVE (',#30, #30, #27, T.);     |
| #29 = CARTESIAN_POINT ('(,0.5,1.,2.);       |
| #30 = VERTEX_POINT (',#29);                 |
| #31 = ORIENTED_EDGE (',* ,* ,#28, T.);      |
| #32 = EDGE_LOOP (',#31);                    |
| #33 = FACE_BOUND (',#32, T.);               |
| #34 = CARTESIAN_POINT ('(,1.,0.,2.);        |
| #35 = DIRECTION ('(-1.,0.,0.);              |
| #36 = VECTOR (',#35,1.);                    |
| #37 = LINE (',#34,#36);                     |

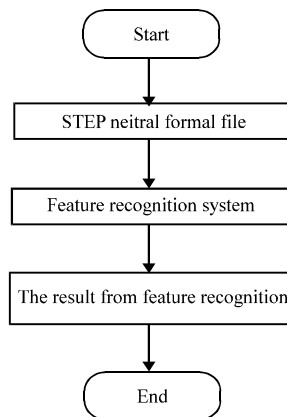


Fig. 2: Feature recognition flow

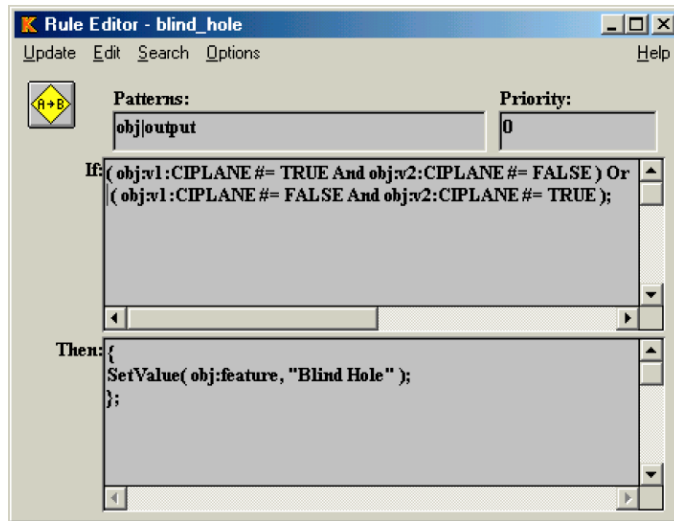


Fig. 3: Rule editor window

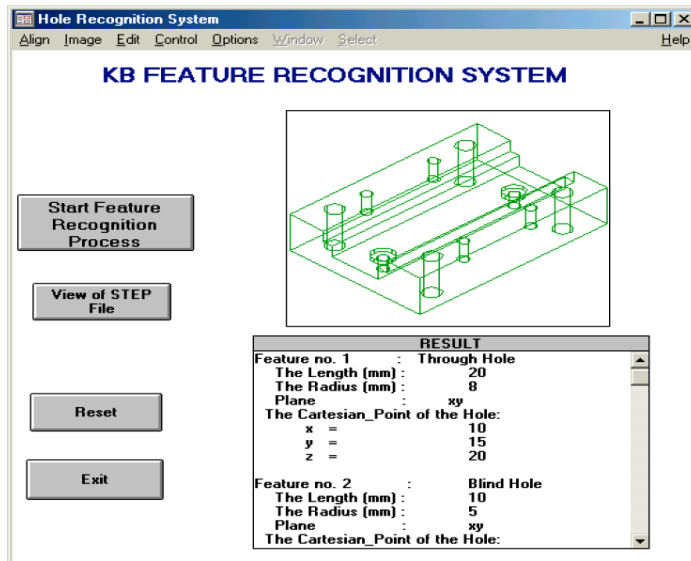


Fig. 4: User interface of the knowledge-based feature recognition system

## RESULTS

A knowledge-based feature recognition system was developed and tested. The database of the developed system can be changed and upgraded by user easily. Currently, the developed system able to interprets 4 rules before giving an answer. The program was tested for all possible scenarios. The system will give an error message if the input data have some errors. In order to validate the developed system, a case study was used to demonstrate the capability of the system.

**Case study (die base plate):** Figure 5 shows the base plate for a sheet metal stamping die. The die base plate contains four through holes, four blind holes, two counter-bored, one through slots and two steps. The counter-bored hole is an intersecting feature. The geometrical information of the features is shown in Table 2.

The partial result of the case study as shown in Fig. 6. The system recognized four through holes with diameter 8 mm, four blind with 5 mm holes, two blind holes with 10 mm and 2 through holes diameter 5 mm. The system could not recognize the counter-bored

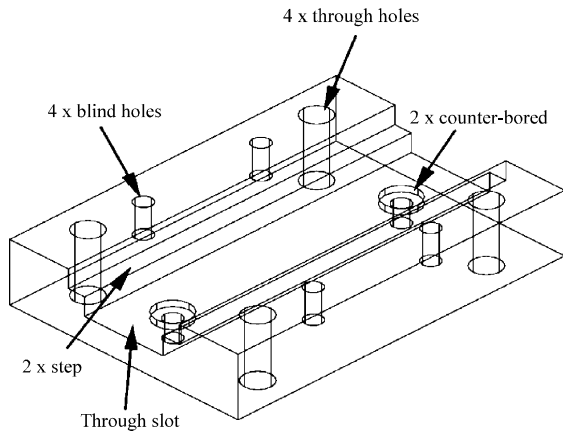


Fig. 5: Base plate for a sheet metal stamping die

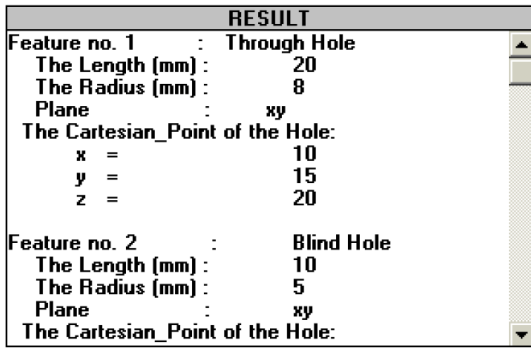


Fig. 6: Partial result of case study

Table 2: Geometrical information of the stamping die's features

| Feature (mm)         | Values   |
|----------------------|----------|
| <b>Blind hole</b>    |          |
| Diameter             | 5        |
| Height/Depth         | 10       |
| <b>Through hole</b>  |          |
| Diameter             | 8        |
| Height/Depth         | 20       |
| <b>Step</b>          | 5x100    |
| <b>Counter-bored</b> |          |
| C-bored              |          |
| Diameter             | 10       |
| Depth                | 2        |
| <b>Hole</b>          |          |
| Diameter             | 5        |
| Depth                | 6        |
| <b>Through slot</b>  | 6x24x100 |

holes due to intersecting nature of the feature. The steps and through slots could not be recognized as well.

## CONCLUSION

An object oriented and knowledge-based feature recognition system was developed. The case study was demonstrated the ability of the system to handle realistic engineering components of prismatic parts under STEP file format. The major achievement of this system is that it is able to recognize blind holes, through holes and slanting holes. Further research is currently being undertaken to include more features such as slots, steps, counter-sunk, counter-bored, etc. The system was flexible and modular type where the database can be upgraded to make the system more comprehensive.

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