World Applied Sciences Journal 21 (8): 1162-1166, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.21.8.2126

Design of a Feature Recognition System for CAD/CAM Integration

[1]Chee Fai Tan, [1]V.K. Kher and [2]N. Ismail

[1]Integrated Design Research Group (IDeA), Faculty of Mechanical Engineering,
Universiti Teknikal Malaysia Melaka, Melaka, Malaysia
[2]Faculty of Engineering, Universiti Putra Malaysia, Selangor, Malaysia

Abstract: This paper presents a methodology for implementing the feature recognition system for achieving the Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) integration goals. The Feature-based modeling is being used to model the solid models. The features being considered in this paper is hole form feature. The input of the feature recognition system is the Standard for the Exchange of Product Model Data (STEP) files. The set of feature recognition rules is generated by using ruled based technique.

Key words: CAD/CAM · Form feature · STEP · Feature-based modeling · Feature recognition

INTRODUCTION

During the past 10 years, research on CAD/ CAM integration had focused on product representation techniques or product modeling that contains more complete product information and providing better interfacing opportunities between CAD and CAM systems. One of the most popular modeling approaches for manufacturing activities involves the use of feature based models [1]. The commercial CAD/CAM marketplace is still very much in its infancy, with many vendors fulfilling limited niches, each with their own particular suite of integrated software modules and data structures. A de facto CAD/CAM integration scheme has yet to emerge [2]. 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.

Feature based modeling is viewed from the manufacturing viewpoint as more suitable for modeling because it deals with shape attributes related to manufacturing. With feature based models, shape information and other information (such as functional and non-geometrical information) can be stored. The potential of feature based CAD in supporting manufacturing applications is based on the possibility to associate feature types with manufacturing process models. Product and process information can be retrieved from the feature-based model to support manufacturing tasks such as process planning, assembly planning and fixture design [1].

Data exchange and system integration have become important consideration in computer-aided systems in order to improve productivity. This had led to the development of neutral format that is used to facilitate product data exchange between manufacturing components. In the early 1980s, National Institute of Standards and Technology (NIST) have adopted STEP to represent product data throughout its life-cycle. The standard is an extension of previously defined standards such as IGES, VDAF and DXF. STEP provides a wider coverage of product model to encompass several computer-aided applications and as a basis towards fully integrated system [3]. There are two main approaches that have been developed in conjunction with feature based models [4]:

- Design-by-features in which the designer create the part directly as a combinations of standard features; and
- Feature recognition which involves computationally recognizing features from conventional geometrical models.

Corresponding Author: Chee Fai Tan, Integrated Design Research Group (IDeA), Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia.
Tel: +6062346710, Fax: +6062346884.

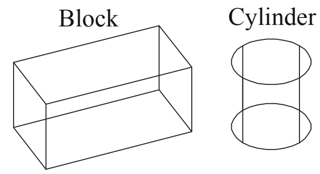
The feature recognition approach is to extract the information that are needed from the CAD database. Feature recognition is a step to reduce the lead time between design and manufacturing. Abdalla [5] had proposed a technique that has the capability to extract required feature directly from the database of a CAD solid modeling system. The technique has the capability to extract the necessary topological and geometrical information from the solid modeler. There are many approaches that have been proposed to recognize and extract the feature from B-rep solid models, which are Artificial Intelligent (AI), Graph-based, Syntactic Pattern recognition and Neural Network (NN) [4].

This paper focuses on feature recognition of form feature from 3D CAD models such as hole by using STEP file. The UniGraphics (UG) CAD system had been adopted in this paper for the feature-based modeling environment and generation of STEP files. The STEP files that consist of geometrical information will used in feature recognition system. The feature recognition rules are generated by using ruled based technique.

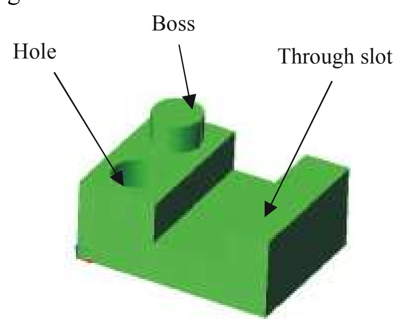
Form Feature and Feature: A feature is an entity or geometric form. Its attributes (dimensions, shape, etc.) are very important for various industrial functions, such as analysis, evaluation and process planning. The feature attributes must be represented explicitly in terms of forms that match available manufacturing knowledge. Example of form features are holes, slots, cuts, rounds and notches [5].

Recently, there are two classifications of features, which are manufacturing features and design features. The manufacturing features used by production planning engineers in manufacturing process planning, whereas the design features is the features that defined by design engineers at the design stage [11-13]. Fig. 1 shows the differences between the two features. Feature contains manufacturing oriented information where it is the basis for integration between CAD/CAM [6]. The feature representation in this paper is using boundary representation (b-rep). According to Ismail [1], the elements of the B-rep data structure has the following characteristics:

- A vertex (v_i) is a unique point in x, y, z coordinates. A vertex is typically shared by three faces or surfaces).
- An edge (e_i) is a finite, a non self-intersecting, directed space curve bounded by two vertices.
- A set of connected edges that form the close boundary of a non-self-intersecting face is known as a loop or also referred to as an edge loop.



(a) Design features



(b) Manufacturing features

Fig. 1: Design Features and Manufacturing Features [6]

- A face is a finite connected, non-self-intersecting region of a closed oriented surface bounded by one or more edge loops.

For B-rep models, it was found out that the more useful data are the topological and the geometrical information. The topology data describes the connectedness between the components while geometry specifies the dimensions and location of each component [6].

Feature-Based Modeling: Recently research towards CAD/CAM integration has concentrated on feature-based models to design the part model. Part description in current CAD model is in the form of basic geometry (faces, lines, points) and topology that is unsuitable for direct application in manufacturing process such as process planning. This problem can be overcome by defining a part in terms of high level geometric entities like holes, steps and slots,. which are called features [7]. The feature-based modelings for this paper is under the UG CAD system. The form features are modeled using the feature available in the UG feature library. In this system, the designer has to create a base feature and add the features by subtracting them from the base feature. The form features being considered in this paper are holes. According to Salomons [8], from a design point of view, feature based modeling has much better potential for computer support of the design process than current non-feature-based CAD system. Features able to help the designer to speed up their design process based on standardization. The feature is able to reduce the design cost, shorter time to market, better design quality as well as able to integrate different applications such as process planning and analysis.

System Implementation: The solid model will produce a STEP file using Unigraphics postprocessor. The STEP file contains the geometrical data of the solid model. The information in the STEP file maintains the structure and dimensions of the solid model and B-rep information of the solid. The STEP representation format can be used in different CAD system.

The feature recognition system in this paper is implemented in three modules which are as follows.

- Module 1 - generate the STEP file. The UG STEP generation tools being used to translate the part to standard STEP representation and store as STEP file.
- Module 2 – interrogate and extract the geometric information of STEP file. The data is then processed and input to the feature recognition system.
- Module 3 – feature recognition using geometrical and rule-based technique.

Fig. 2 Shows the methodology for feature recognition in this paper.

In this paper, the hole has been proposed to use in feature recognition system. The taxonomy of a hole is shown in Fig. 3. The STEP file contains the entities such as circles, lines, planes and text. Every entity has associated with various attributes like color and linetype.

To take an example, the line entity in STEP may look as follows:

#37= LINE(‘’,#34,#36); the entity type
#39=CARTESIAN_POINT(‘’,(2.,0.,2.)); the first point
#41=CARTESIAN_POINT(‘’,(0.,0.,2.)); the second point
#35=DIRECTION(‘’,(-1.,0.,0.)); the extrusion direction

The rule-based approach uses AI technique to develop a set of rules. According to Ismail [9], the algorithms identify a feature based on certain pre-specified rules that are characteristic to the feature. The following set of heuristic rules is used to describe a through hole feature [9]:

IF circular edges are found and
Point in *cir_edge1* and *cir_edge2* is 1
THEN identify *through hole*

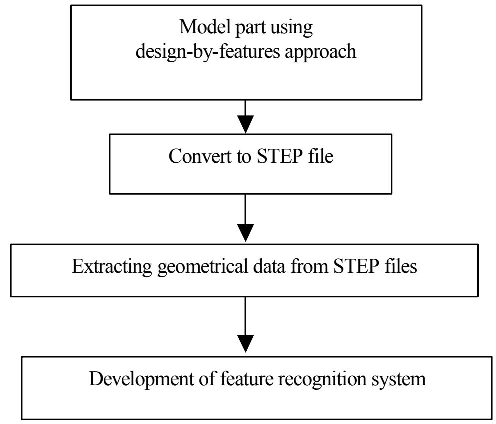


Fig. 2: The methodology for feature recognition

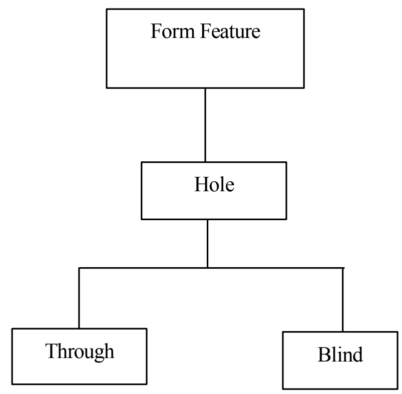


Fig. 3: Taxonomy of features (Hole)

RESULT AND DISCUSSIONS

The B-rep is a explicit feature representation. A B-rep solid model is constructed using entities like line (or edges), faces and points (or vertices). Fig. 4 and Fig. 5 shows the examples of B-rep model of through and blind hole which is proposed to be recognize in this paper.

The B-rep models are converted to STEP representation format through UG postprocessor [10]. The output of the 3D model for Figure 4 in the STEP representation format is shown in Fig. 6.

The rules for feature recognition are proposed in this paper. The type of a form feature can be recognized by using the following approach:

IF [A] THEN [B]

where A are the condition and B are the results. The rules that had been proposed for this paper is used to recognize the through hole and blind hole. The recognition of through hole was proposed through the following rule:

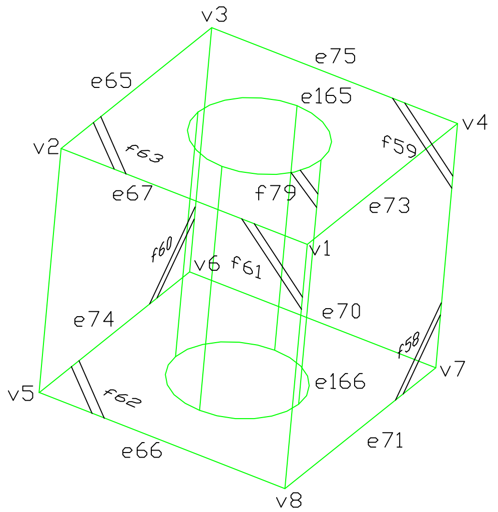


Fig. 4: B-rep model of a part with through hole

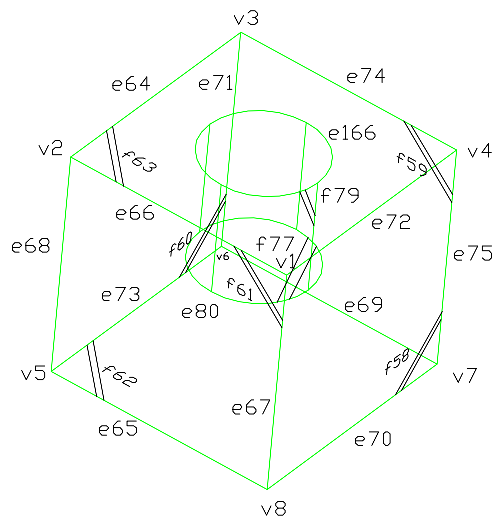


Fig. 5: B-rep model of a part with blind hole

```
#19=CARTESIAN_POINT('',(0.,0.,0.));
#20=DIRECTION('',(0.,0.,1.));
#21=DIRECTION('',(1.,0.,0.));
#22=AXIS2_PLACEMENT_3D('',#19,#20,#21);
#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);
#38=EDGE_CURVE('',#40,#42,#37,.T.);
#39=CARTESIAN_POINT('',(2.,0.,2.));
#40=VERTEX_POINT('',#39);
#41=CARTESIAN_POINT('',(0.,0.,2.));
#42=VERTEX_POINT('',#41);
#43=ORIENTED_EDGE('',*,*,#38,.F.);
#44=CARTESIAN_POINT('',(2.,1.,2.));
#45=DIRECTION('',(0.,-1.,0.));
#46=VECTOR('',#45,1.);
#47=LINE('',#44,#46);
#48=EDGE_CURVE('',#50,#40,#47,.T.);
#49=CARTESIAN_POINT('',(2.,2.,2.));
#50=VERTEX_POINT('',#49);
#51=ORIENTED_EDGE('',*,*,#48,.F.);
#52=CARTESIAN_POINT('',(1.,2.,2.));
#53=DIRECTION('',(1.,0.,0.));
#54=VECTOR('',#53,1.);
#55=LINE('',#52,#54);
#56=EDGE_CURVE('',#58,#50,#55,.T.);
#57=CARTESIAN_POINT('',(0.,2.,2.));
#58=VERTEX_POINT('',#57);
#59=ORIENTED_EDGE('',*,*,#56,.F.);
#60=CARTESIAN_POINT('',(0.,1.,2.));
#61=DIRECTION('',(0.,1.,0.));
#62=VECTOR('',#61,1.);
#63=LINE('',#60,#62);
```

Fig. 6: Output of STEP file for part with through hole

IF
Total circle number = 2 &
Total cylindrical number = 1 &
Face type = cylindrical_surface &
The two circle are subtract from the adjacent plane
The two circle are adjacent to cylindrical_surface

THEN
Feature type = hole (through)

The blind hole was recognized through the following proposed rule:

IF
Total circle number = 2 &
Face type of one circle = plane &

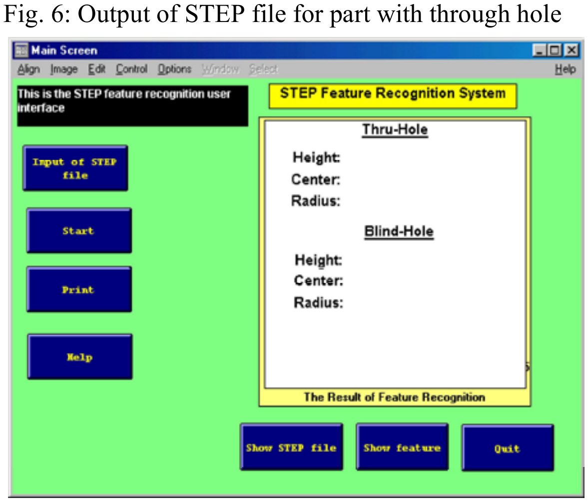


Fig. 7: The User interface main menu

Total cylindrical number = 1 &
Face type = cylindrical_surface &
One circle is subtract from the adjacent plane
One circle is adjacent and perpendicular to cylincrical - surface

THEN
Feature type = hole (blind)

The proposed rules for through hole and blind hole will input to the feature recognition system. The rules will use to define the STEP file accordingly. The user interface for feature recognition system also being developed in this paper. Fig. 7 show the user interface and the parameter selection menu respectively.

CONCLUSION

A prototype feature recognition system has been proposed to support the CAD/CAM integration. Currently the form features recognized through holes and blind holes. The part is modeled using the design-by-features approach of the UG CAD system module. Then geometric description of part is presented in STEP neutral data format. For the purpose of feature recognition process, the STEP format must be sorted first. The rule-based technique had been proposed for this paper in order to extract the features data. The user interface also being proposed for the feature recognition system. For future research, the recognition of complex hole features and other features such as slots, pockets, bosses, step and ribs can be developed.

REFERENCES

1. Ismail, N., N. Abu Bakar, M.R. Osman and S.M. Sapuan, 1999. Feature Recognition Approach for Computer Aided Manufacturing. Proceeding of Worlds Engineering Congress 1999- towards the Engineering Vision: Global Challenges and Issues, pp: 325-329.
2. Regli, W., 1995. Geometric Algorithms for Recognition of Feature from Solid Models. Ph.D thesis, University of Maryland.
3. Shaharoun, A.M. and J.A. Razak, 1999. STEP-Based Central Repository for Product Data Sharing Among Computer-Aided Systems in Manufacturing Applications. Proceeding of Worlds Engineering Congress 1999- Towards the Engineering Vision: Global Challenges and Issues, pp: 215-219.
4. Shah, J.J. and M. Mantyla, 1995. Parametric and Feature-Based CAD/CAM. John Wiley and Sons, Inc. Tseng.
5. Abdalla, H.S. and J. Knight, 1994. An Expert System for Concurrent Product and Process Design of Mechanical Parts. Proceeding Institution Mechanical Engineers, 208: 167-172.
6. Ismail, N., C.F. Tan and S.M. Sapuan, 2000. Form Feature for Concurrent Engineering. 2000 TENCON Proceedings: Intelligent Systems and Technologies for the New Millennium, 3: 468-471.
7. Ismail, N. and A.N. Bakar, 1997. Recognition of Features from B-rep Solid Models. ASEAN Journal of Science and Technology Development, 14(2): 35-49.
8. Salomons, O.W., 1995. Computer Support in the Design of Mechanical Products. Ph.D Thesis, University of Twente.
9. Ismail, N. and N. Abu Bakar, 1997. Recognition of Machined Features from Solid Database of Prismatic Components. Pertanika Journal of Science and Technology, 5(2): 231-240.
10. Unigraphics User Menual Version 13, 1997 (Electronic Data System Corporation, Unigraphics Division, MO USA).
11. Sunil, V.B. and S.S. Pande, 2008. Automatic Recognition of Features from Freeform Surface CAD Models. Computer-Aided Design, 40(4): 502-517.
12. Ran, J.Q. and M.W. Fu, 2010. Design of Internal Pins in Injection Mold CAD via the Automatic Recognition of Undercut Features. Computer-Aided Design, 42(7): 582-597.
13. De Martino, T., B. Falcidieno and F. Giannini, 1994. An Adaptive Feature Recognition Process for Machining Contexts. Advances in Engineering Software, 20(2-3): 91-105.