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CAD/CAM Integration Based on Machining Features for Prismatic Parts

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ABESTRACT

In recent years, various researchers have come up with different ways and means to integrate CAD (Computer Aided Design) and CAM (Computer Aided Manufacturing). The selection of machining parameters is an important process planning function for manufacturing processes.Typically, machining parameter selection is done manually. The user still needs to manually create the machining operations and define geometry, cutting tool, and various parameters for each operation. Design data from a CAD model cannot be directly used in a CAPP (Computer Aided Process Planning) system due to the difficulties arising from different feature viewpoints in each application and in various feature representations. To create a process-planning model automatically using machine features, feature mapping or conversion is the key issue to solve this problem.

Keywords: CAD,CAM, Feature recognition, CAPP

1. Introduction

The main objective of any manufacturing organization is to produce high quality products at the lowest possible cost. The growing complexity of achieving this objective, with sharply rising costs and increased competition, has forced the industry to look for alternatives to the traditional approaches to design, manufacturing and management.

1.1. Related Work

There have been considerable researches on the feature recognition systems. Automated feature recognition has been an active research area in solid modeling for many years and is considered to be a critical component for integration of CAD and computer-aided manufacturing. Mike Pratt [6] gave an overview on the three major algorithmic approaches for feature recognition and mentioned several drawbacks of them also proposed several open research areas. JungHyun Han [7] made a survey on feature recognition and merits of several algorithms of feature recognition: graph pattern matching, cell based decomposition, convex hull decomposition and Hint based reasoning. In graph-based approach, boundary representation of the part is converted into a graph which involves a set of nodes and their attributes. Joshi and Chang [8] developed a graph named the Attribute Adjacency Graph (AAG) to represent features in which each face of the part is represented as a node, and each edge or face adjacency is represented as an arc. SashikumarVenkataraman[9] presented a graph based frame work for feature recognition. The feature recognition step involved finding similar sub graphs in the part graph. The novelty of this framework lied in the usage of a rich set of attributes to recognize a wide range of features efficiently. W.F. Lu [10] gave an approach to recognize features from a data exchanged part model. A litany of algorithms for the identification of design and machining features are proposed. A.F.M. AnwarulHaque [11] explained manufacturing feature recognition of a rotational component using DXF file. In this work geometric information of a rotational part is translated into manufacturing information through a Data Interchange Format (DXF). Emad S. Abouel Nasr [12] discussed a methodology for extracting manufacturing features from CAD system. Geometric modeling is done in three principal ways. They areWire frame modeling, Surface modeling, Solid modeling, and Constructive Solid Geometry (CSG).

There is a lot of research on feature-based CAPP, which focuses on the link with design and process planning, but not much research focuses on the link with process planning and manufacturing. Liang, et al. [22] report the development of a STEP based tool path generation system in a Unigraphics environment for rough machining of planar surfaces. Miao, et al. [23] demonstrate the use of features in automating certain process planning tasks and integrating CAD and CAM modules in a commercial CAD/CAM system (I-DEAS).

2. Geometric Modeling

Geometric modeling is the process in which a geometric model is created to represent the size and shape of a component in computer memory. There are generally three types of modeling scheme in common use to represent a physical object in CAD/CAM systems. They are wire-frame modeling, surface modeling and solid modeling schemes. An example for each system is shown in Figures1, 2 and 3.

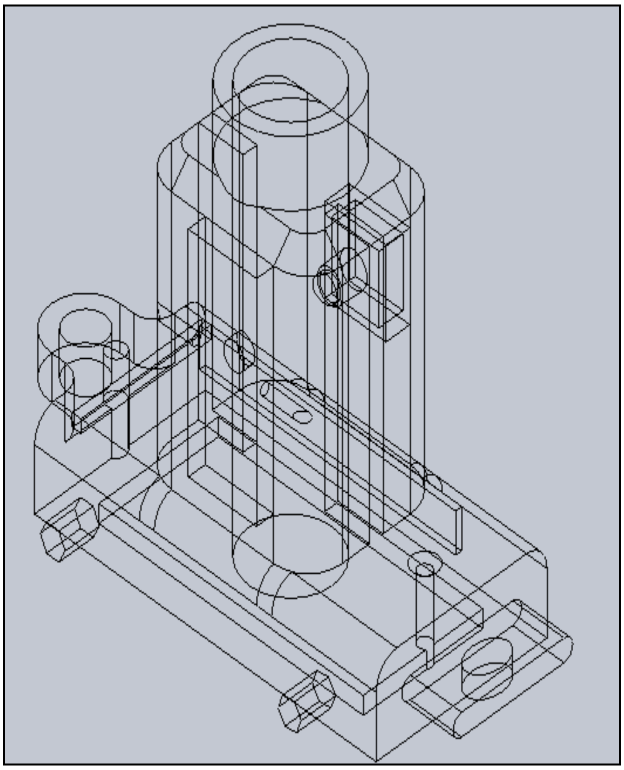

Fig. 1: Wire-frame modeling.

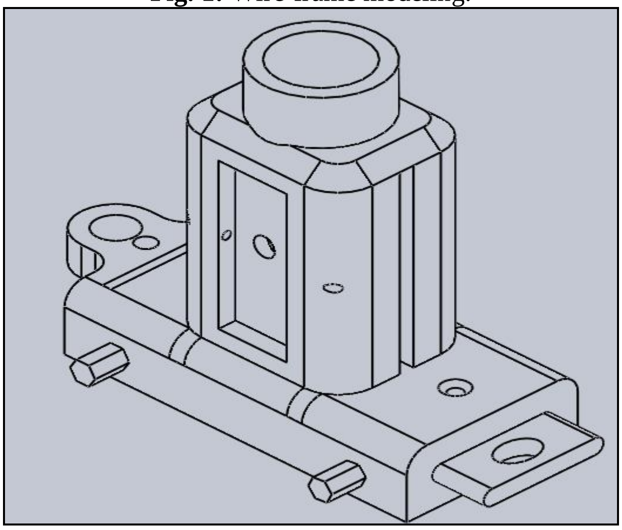

Fig. 2: Surface modeling.

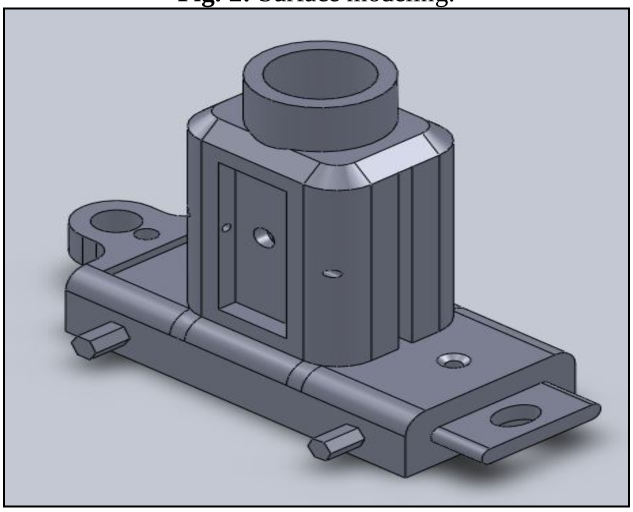

Fig. 3: solid modeling.

Wire-frame modeling is one of the simplest and most basic methods of geometric modeling. It is most commonly used to define computer models of parts especially in computer aided drafting systems. Wire-frame modeling uses points, lines, circles and arcs to define objects. The wire-frame models are simple and easy to create, and they require little computer time and memory, even inexpensive computers can cope with the processing needed. However, it has a number of limitations.

2.1 Feature Based Design and Feature Recognition

Features have been claimed to be the enabling technology for many CAD/CAM applications. There are many published definitions of the concept of a feature. Even though these definitions seem to be dissimilar, they all consider features as entities which are of semantically higher level than the pure geometric elements typically used in solid modeling systems. The geometric aspects of features are defined as volumes enveloped by a set of real and imaginary faces. Geometric elements are solid primitives in CSG type solid models (blocks, cylinders spheres, conical) or boundary elements used in B-Rep type solid models (faces, edges, vertices).

2.3 STEP (Standard for the Exchange of Product data) Standard

STEP is the international standard for geometric and non-geometric data transfer between heterogeneous CAD, CAE and CAM systems. STEP, sometimes called Standard for External Representation of Product Model Data, STEP physical file gives the geometric and topological representation of a part in terms of its advanced boundary representation (B-Rep). Based on AP203

STEP has a three phase (layer) architecture; application layer, logical layer and physical layer In the first phase which is an interface between the standard and the user, the application model (information structure) is expressed. The models for each specific area of interest are developed at the application layer. These models are called topical models. The output of physical layer is a physical file (STEP file). A detailed content about the STEP development layers are given in the following paragraphs.

The application layer is composed of application area, shape models, geometry, topology, form features, dimensions and tolerances. The first thing to do is to decide about the application areas, like FEM, drafting, electrical and electronic applications, etc., of the product. Then, a shape model which is specific to the chosen application area is to be selected. Wireframe, surface or solid modeling associated with CSG or B-Rep schemes might be selected as the shape model for the particular applications. A common scheme is used for the definition of 2D and 3D geometry in the STEP. The geometric entities which are used to define the geometry of a component involves; coordinate system, axis, point, vector, curve, surface, and so on.

Topology is another element in the application layer. The basic topological entities are vertex, edge, face, loop and shell. Vertex is the primitive entity among the hierarchy of topological entities. All other topological entities are defined in terms of vertices [31].

The geometric associations for vertex, edge and face are point, curve and surface, respectively. The simple definitions of the topological entities are as follows [33]:

- A vertex is the topological entity corresponding to a point.
- An edge is the connection between two vertices.
- A face is a portion of a surface bounded by loops. It is represented by its bounding loops and has a topological normal.
- A loop is combined by stringing together vertices and edges beginning and ending at the same vertex. It is typically used to bound a face lying on a surface.
- A shell is used to bound a region. It is constructed by joining faces along edges. The shell is represented by a collection of faces.

In Figure 4 can divided for prismatic feature into two main groups which are local and gross. The local feature contain three types which are, Face-based (holes), edge-based (slots) and corner-based (step type). The gross can divided into two big types which are rectangular type and contoured.

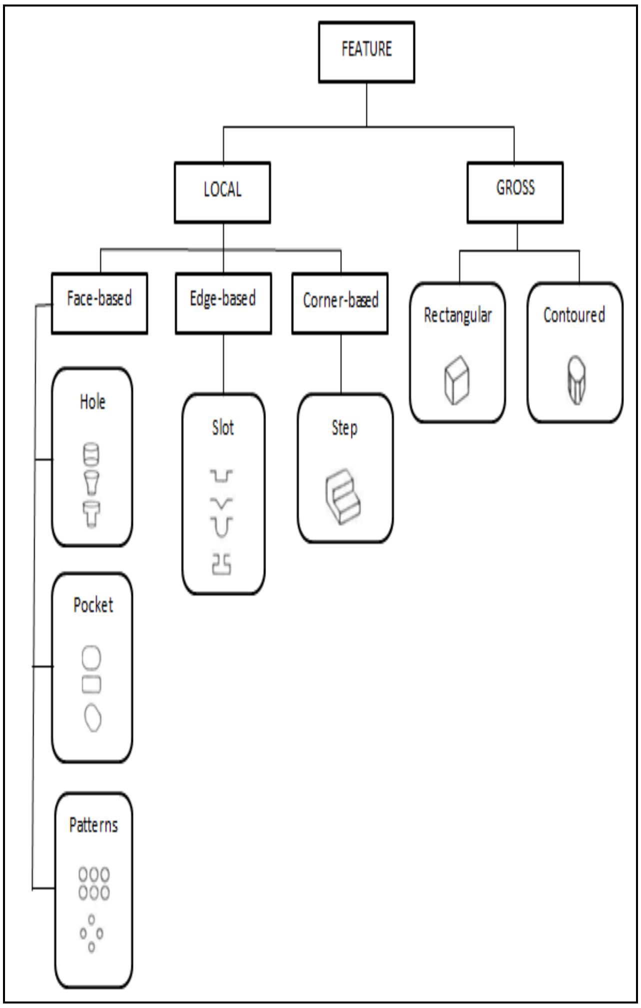

Figure 4: Feature Taxonomy

The place of "determination of sequence of operations" in CAD/CAM integration is illustrated in Figure 5.

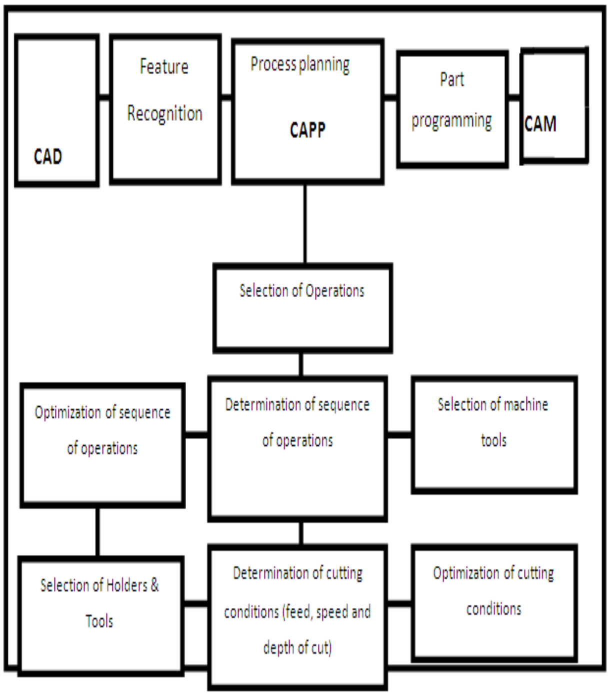

Figure 5: Corner Stones in a Typical CAD/CAM Integration.

in Figure For the last decades, a large number of design-for manufacture (DFM) rules (guidelines)and features as shown 6 have been developed [13].

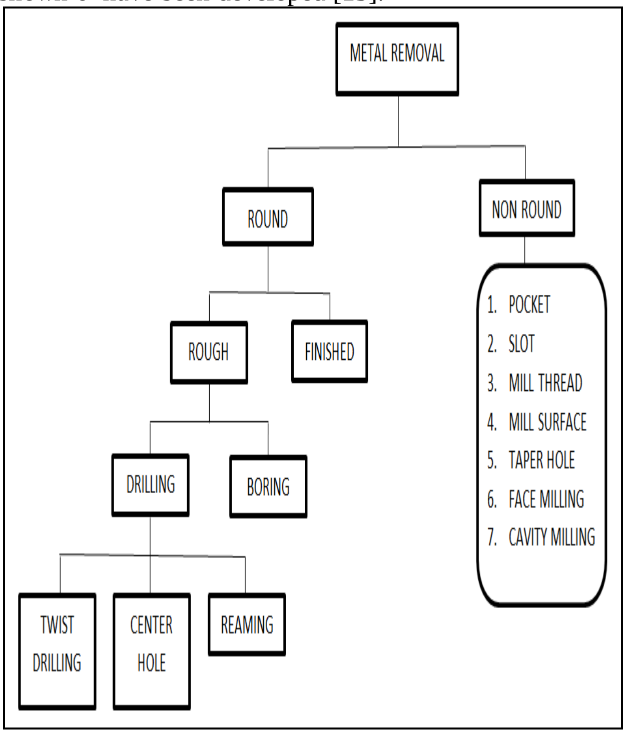

Figure 6: Pointing DFM rules to processes

The figures 8,9 shows the different types of features in the solidworks environment and all details as shown in the figure and can converted it to text file format by STEP file format.

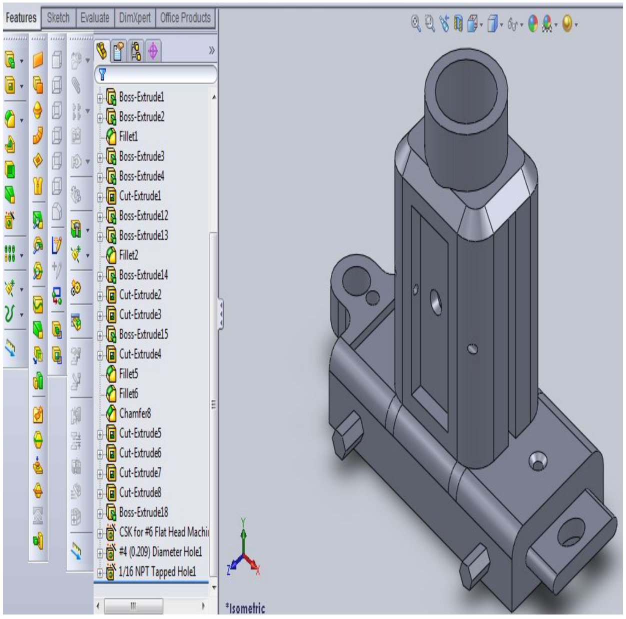

Figure 8: Isometric with features

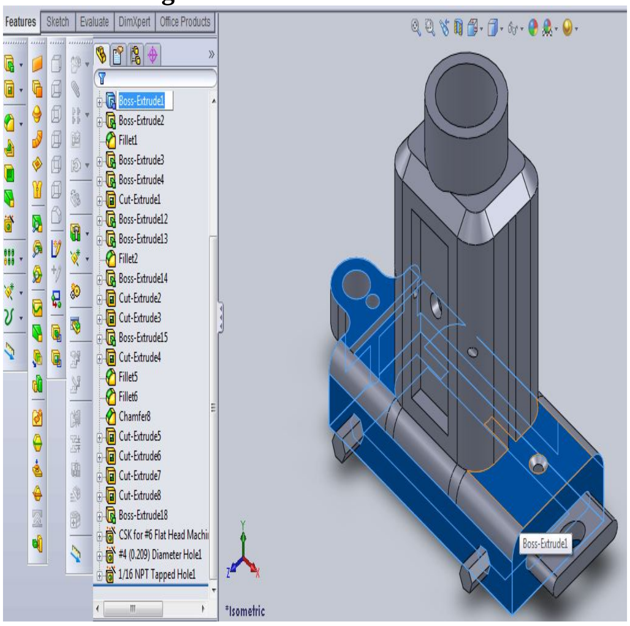

Figure 9: Boss-Extrude

4. Conclusions

Machining feature is a key concept to seamlessly integrate CAD, CAPP andCAM systems. The work has discussed the integration of CAD/CAM systems basedon machining features. A prototype is developed in conjunction with a CAPP system,FBMach, and a commercial CAD/CAM system, Solidworks is used to demonstrate the CAD/CAMintegration for prismatic parts. Machining features are utilized to definemachining geometries and eliminate the necessity of user interventions in integration. Oncethe features are recognized and the process plan is generated from the solid model,the information is directly available to the system and tool paths can be automaticallygenerated with solid models and process plans.

5. Future research

- ❖ The integrated system is implemented for prismatic features and relatedoperations and does not support turning operations, or multi-axis machiningoperations. For future research, turning operations as well as complex multi-axismilling operations can be included in the system. Robust automatic featurerecognition for turning features and complex milling features is needed for theintegration. The data models of process plan and CAM object library will need to beexpanded to include different operations and their associated objects.
- ❖ Feature recognitions are promising on CAD/CAM integration although its development isstill in the initial stage.
- ❖ In a process plan if the cutting tool and all other cutting conditions are thesame, the automatically created operations may be combined to optimize the processplan. The analysis and combination of drilling operations is easy to take into considerations but, Milling operations also need to be analyzed and combined for optimization.

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