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# A System for Extracting Product Features from CAD Models – A STEP Approach

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**Abstract**

Extraction of Product features finds a major application in industries practicing CAM techniques. The Product development time & Product features are greatly dependent on the accuracy of Product data extracted. This is quite a complex & challenging task, as a mix of geometric & technological features are involved into it. Consistency of Product data across all the modules of its lifecycle is important, in order to make an automated product realization system possible. Present work attempts to address this concept by using STEP for automatically extracting Product features from a CAD Product model using programming, database and modeling tools. An effort has been made to develop software for feature recognition to determine the product attributes like cost, technical specifications etc with an emphasis on manufacturing attributes, thereby determining the sequence of operations to be performed for product realization. In order to prove the concept, STEP file based AP203 has been used. An attempt is made to simulate AP238 effect by querying the users interactively, for manufacturing attributes. However, it is possible to extend the application of AP203 to AP238, hence dealing not only with the product details but also understanding the manufacturing information for the feature.

**Keywords:** Product data, feature extraction, STEP

## 1. INTRODUCTION

Most of the research carried out so far, focuses more on to feature extraction from standard CAD models viz. wire frame, surface and solid. Much of this work is based on DXF, IGES or other suitable design interfaces. However, current focus in CAD/CAM technology is Product model and the associated design interfaces. A Product model is one, which has the geometric as well as the technological information embedded into it.

So far the world of CAD/CAM has viewed the *International Graphics Exchange Standard* (IGES) as its translation standard for years, using the system to move two-dimensional models from one program to another. While IGES does, in fact, do a good job of transmitting basic geometry, another translator—the *Standard for the Exchange of Product Model Data* (STEP)—has been gaining on IGES in popularity. STEP goes considerably further than just transmitting geometry; it provides users with the ability to express and exchange digitally useful product information throughout a product's life cycle, including design, analysis, manufacturing, and support. The objectives of STEP include the creation of a single international standard to cover all aspects of CAD/CAM data exchange and the implementation of this standard within industry, superseding all others **[6]**,**[4]**.

Further Manufacturing or CAM modules expect the complete geometrical as well as technological information from CAD models in a form acceptable to them **[1]**. STEP helps serve this purpose. STEP is a proactive effort, the focus being placed on developing a standard that caters for various user groups. These user groups are usually associated within an industry or according to a common application such as CAD data, which can be used throughout multiple industries **[5]**. STEP is an international effort that goes beyond geometry and aims to represent product data throughout a product’s life cycle

The primary goal of the standard is to provide a neutral platform for product data exchange over the entire life cycle of a product. It is possible to avoid redundancy of data needed across the applications such as Finite Element Analysis, Computer Aided Process Planning etc **[7]**. This makes it the keystone for integrating a company's engineering processes. STEP if used with World Wide Web technology can enable a company to build an open system and make engineering information available throughout its operations **[3]**.

The STEP file is the input for Feature Extraction process. “*The process of recognizing the feature of any model, analyzing them and correctly interpreting the model is known as Feature Extraction*”. This includes use of modeling software and the database technologies **[8]**.

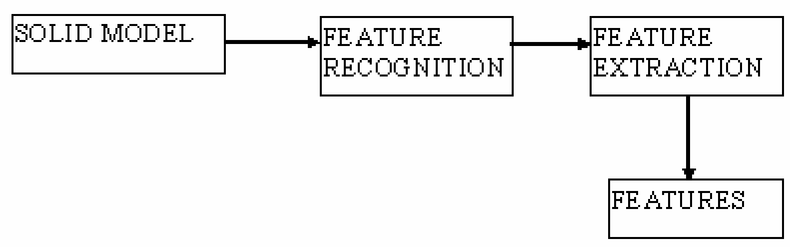



Fig. 1: The Feature Extraction Process

An overview indicates that the concept of Automatic Feature Extraction from CAD models has gained attention only in the last decade. Researchers have considered both 2-D and 3-D CAD models. Meeran and Pratt (CAD V25, 1993) and Deshpande (1996) have provided a successful basic setup for extracting the features from 2-D CAD models using DXF interface **[2]**.

IGES interface has also been used extensively in the feature extraction from 3-D CAD model. Considering the inherent problems in these interfaces like frequent revisions, lengthy word structures and support available only for the geometric data, the focus has now shifted to STEP interface. In the recent past, few researchers have used STEP successfully but much of this work is oriented towards understanding and development of protocols **[5]**. Off late, some good work on AP238 has been reported **[9]**. However, the algorithms and the considerations used in all the recent work are quite complex and oriented towards high-end and hi-tech applications and users. There is a need to encourage a common user to use STEP effectively. In the perspective of these arguments, present work tries to address these issues, using a simple and logical algorithm and friendly user interface. Also, the system uses AP203 with an effect of AP238.

## 2. WORK METHODOLOGY

The work involved is quite challenging, as a simple and convenient look has to be imparted to a complex idea. It is also essential that, the outcome have to be understandable and useful
The system works in accordance with the following procedural steps.

1. Creation of the CAD model in any CAD modeler capable of supporting STEP AP203.
2. Generation the STEP file of the model created.
3. This STEP file basically consists of geometric features, as per the standard application protocol AP203. The file is analyzed for extraction of geometric features based on *"3-Edge Theory"*. The logic used works in terms of the edge, vertex and the Cartesian point in sequence.

*4.* The extracted geometrical features are displayed and the user is requested to provide associated technological attributes. Using these inputs viz. feature and technological data, the system identifies and sequences the manufacturing processes at a *macro level.*

The file system of CAD Models based on AP203 gives nominal geometric information. This information when analyzed shows that there is a hierarchy in identifying parameters to define the geometry. Hence, the faces, edge loop, edges, vertex and Cartesian points are traced respectively from the STEP file. The final set of Cartesian points defines parameters like line, arc, cylindrical surfaces, etc. Output is in the form of length, width and height of simple features like slots and pockets or a set of Cartesian points to be traced by tool for complex irregular profiles.

The extracted features are grouped in to two categories, viz. "Simple" and "Complex" based on the geometry, for the analysis. The present work deals with a unique method to identify the features. The STEP file consists of edge curves, lines, arcs and Cartesian points. Simple features are extracted using *"3 Edge theory"* which derives the benefit of the edges of the feature being related to each other in some way or the other. The logic used is explained in the next section with examples.

## 3. SIMPLE FEATURE RECOGNITION AND EXTRACTION

The logic for simple feature recognition is explained with an example of Rectangular slot (Refer Fig 3).

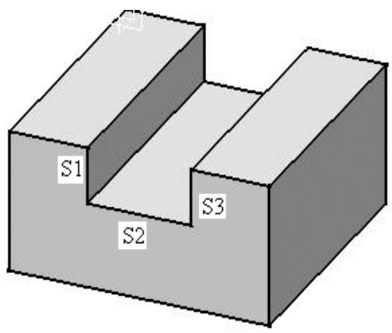



Fig. 3: Rectangular Slot 100 X 20 X 10 mm in a block

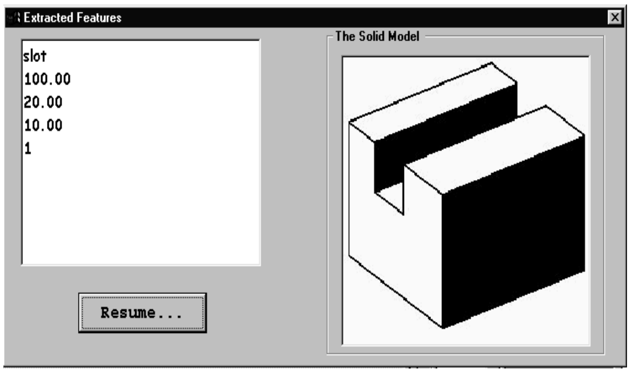
The logic of *"3 Edge theory"* used here is as follows:

- Identification of line and numbers thereof.
- Establishing the string representing an EDGE CURVE.
- Analysis of the string, character-by-character to find the hash codes corresponding to vertex points and then the Cartesian points.
- Identification of the line type viz. horizontal, vertical or inclined.

- Inferring the relationship between the lines e.g. intersecting, equal or unrelated
- Recognition of the rectangular slot based on above analysis. Rectangular slot feature is established using the inference that the edges (S1, S2) & (S2, S3) are perpendicular to each other.

After analyzing, the Output is displayed in the form of length, breadth, height and the number of slots. (Refer Fig.4). The Logic used to get the output is shown in the flowchart. (Refer Fig. 5)

Fig. 4: Output of Rectangular slot after analyzing the STEP file



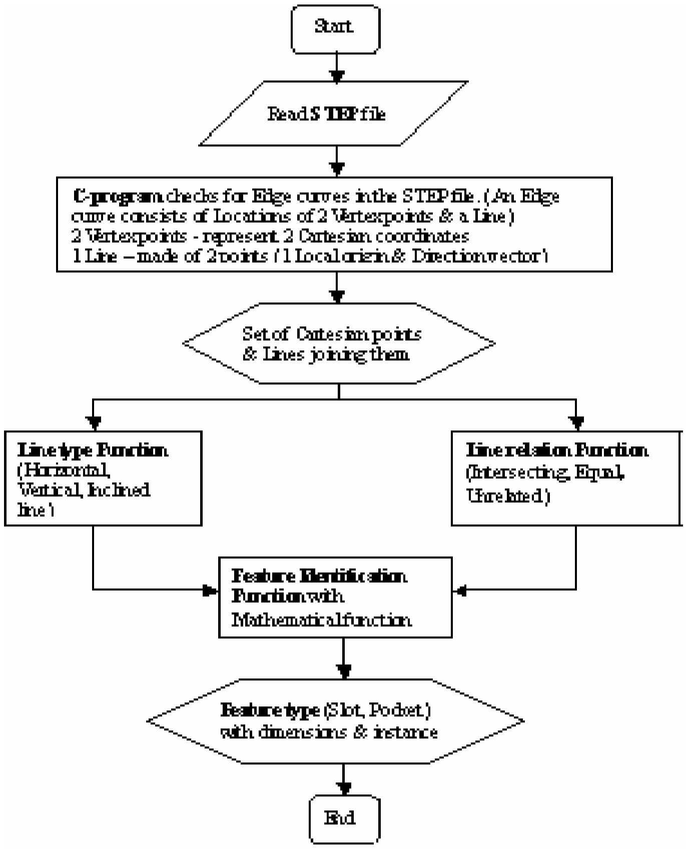



Fig. 5: Flowchart depicting the Logic used in programming

The details of the manufacturing processes and their sequence, needed for the feature is displayed to the user based on the technological information submitted. An in-built expert system module is activated for the same. (Refer Fig. 6).

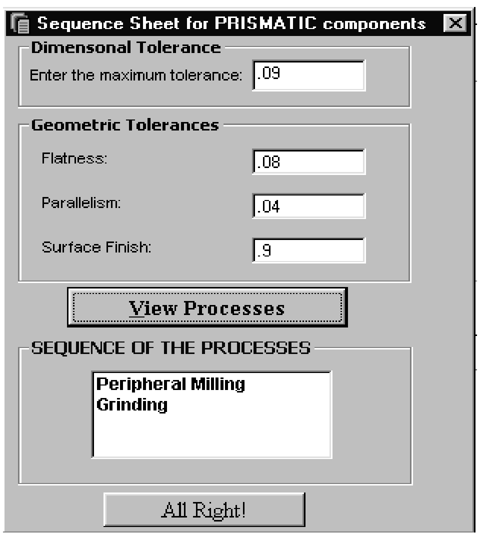



Fig. 6: Machining Sequence

## 4. COMPLEX FEATURE RECOGNITION AND EXTRACTION

In case of the complex and irregular features, the logic is similar to *"3 Edge theory"* with an additional *C-zero continuity test*. An example of feature extraction from an irregular pocket is illustrated with the help of Fig. 7 and 8.

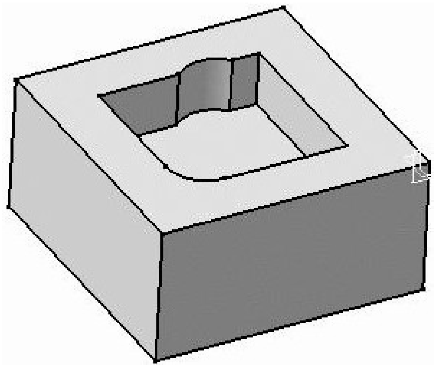


Fig. 7: Irregular Pocket with uniform depth 50 mm in a block

The logic utilized here is based on C-Zero Continuity, i.e. the end point of the first entity is the start point for the second entity and the end point of the second entity is the beginning point of the third entity and so on.

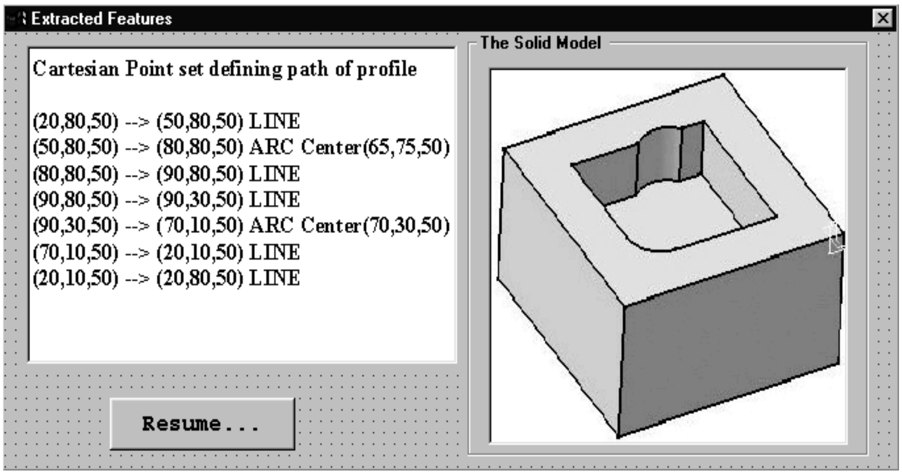



Fig. 8: Output of Irregular pocket after analyzing the STEP file

Once the output is obtained, the machining sequence can be obtained as described in the previous section for Simple feature extraction.

## 5. CONCLUSIONS

In the past, few researchers have attempted to extract features using interfaces such as DXF, IGES etc. However, STEP appears to be most potential interface as it has a versatile library of entities and neutral interface for many Modeling packages. Even though the File is lengthy and complex, a well-defined and correlated structure exists as the schema-based language EXPRESS is used in designing it. In most of the reported works on STEP, AP203 or AP214 is used. Considering the future scenario, based on AP238, the present work provides an excellent ground for extrapolating from AP203 to AP238, using existing versions of CAD modelers without AP238 support.

The system works with a simple and smooth flow in a friendly interactive environment. In order to prove the concept, the work has been designed only for some simple prismatic features and complex contours. This can be extended to other features too, limited by the feature library available in STEP.

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