A Feature Extraction Algorithm for Process Planning

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Abstract

This paper is to provide an integration approach between design and process planning for mechanical parts ,using feature recognition. We develop a method to extract each individual feature of an object from 3D modeling data using face-edge graph based algorithm and then propose an approach to recognize the volumic form features using heuristic rules. We demonstrate the proposed approaches are effective for such basic shapes as pocket, slot, through hole, etc.

1 . Introduction

The link between a product design stage and other related stages, such as process planning and manufacturing, is not easy to implement since different kinds of information are required at those stages. Recently the feature technology has been introduced to enhance this link. Features can be aspects of form or other attributes of a part, such that these can be used in reasoning about design or manufacturing. Feature technology can be classified into two categories : design-by-feature and feature recognition[1]. Various researches for recognizing form features have been performed. These include : syntactic pattern recognition approaches[2], volume decomposition approaches [3], rule based approaches[4] and graph-based approaches[5]. None of the methods developed is perfect to be applied because the same geometric features may be conceived as several different features depending on their applications. This paper describes a generic feature recognition method from the boundary representation (B-rep) data using face-edge adjacent graph.

2 . Feature Extraction

The first step is to convert the B-rep data into face-edge adjacency graphs based on face-edge relationship and extract the generic feature from the graph. From the 3D modeling data, we find faces and the corresponding edges, and then assign the adjacency and convex/concave information between faces from the topological relationships of parts.

Figure 1 identifies a simple example of face-edge graph and a cut node.

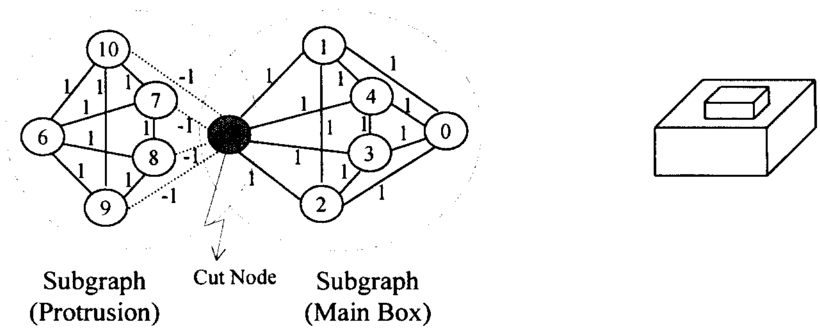


Figure 1. Face-edge graph and Cut Node

At first the extraction module finds each face and searches corresponding edges from the B-Rep data structure and then stores them in temporary variables. Secondly, it compares the edges of each face. If there are identified edges between two faces, adjacency number 1 or –1 is provided. For the faces connected each other with less than 180 degree which leads convex relationship, a positive 1 is assigned and for the faces connected each other with greater than 180 degree which leads concave relationship, -1 is assigned. If there is no connection each other, 0 is allocated. In addition, number 0, 1 or 2 are marked to every node itself in accordance with the status of the face (for example, 0 for concave surface, 1 for plain surface, and 2 for convex surface), which is represented in the diagonal of the adjacency matrix.

In figure 1, although one of the nodes except node 5 is removed in the graph, the graph still can maintain one whole body. However if node 5, called cut node, is removed, the whole graph is bisected into two. Therefore, the number of subgrahps can be detected using cut node concept. If there is a node causing disconnectivity of a graph or a subgraph during random removal process of every node, the node is a candidate of cut node. We also employed virtual edge for a cylindrical face that is not clearly denoted as a cut node. Figure 2 shows a cut node using virtual edge concept.

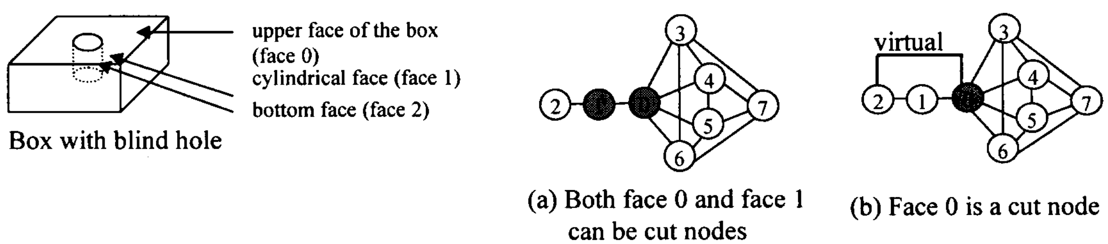
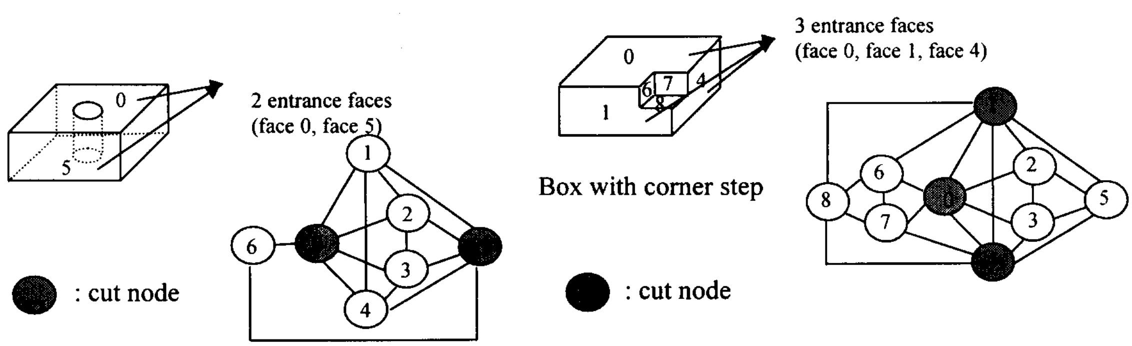


Figure 2. Virtual Edge for Cylindrical Face

The subgraph extraction method using cut node can be limited when there are multiple entrance faces such as Figure 3. To solve this limitation, we extended the cut node concept up to multiple cut nodes concept.

By this procedure using the double cut nodes, the features which have two entrance faces can be extracted. The next procedure is continued shown as Figure 4.



(a) Two cut node case

(b) Three cut node case

Figure 3. Example of Multiple Cut Nodes

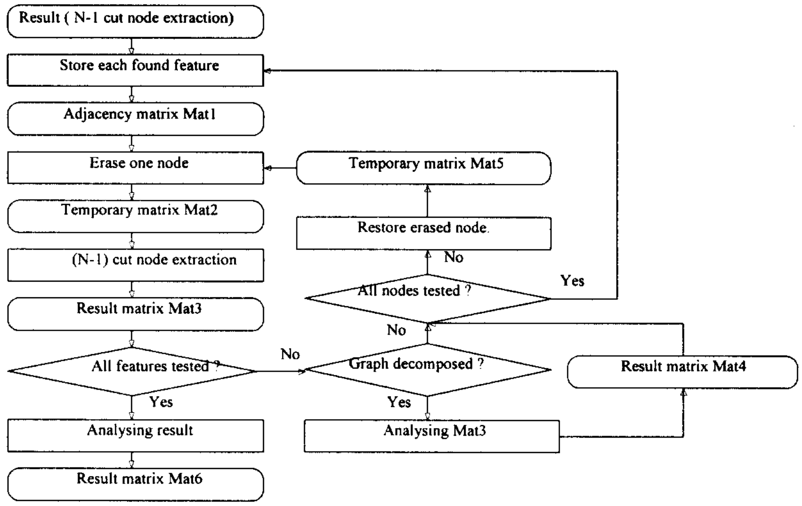


Figure 4 Algorithm for Feature Extraction Using Multiple Cut Nodes

3 . Feature Recognition

In the second step, the extracted features are recognized according to requirements of individual application. First, the base object-raw material- is selected by testing if all edges of an object are convex. This base object is considered as a reference object and a feature in this reference object is recognized by applying heuristic rules. The heuristic rules are based on the information of the face-edge relationship, the number of entrance face and convex/concave property. This feature is selected as a reference object, and another feature in this reference is recognized using the heuristic rules. Table 1 shows the partial rules and recognition procedure shown as Figure 5 is continued until all features are recognized.

Table 1 Partial Partial Rules

App. Feature	E.F	Rule
Pocket	1	Faces not connected to entrance face are connected to other faces in concave.
Blind Hole	1	Surface type of face connected to entrance face is cylindrical.
Blind Slot	2	Faces not connected to entrance faces are connected to other faces in concave.
Through Hole	2	All faces are connected to entrance faces
Corner Slot	3	Faces not connected to entrance faces are connected to other faces in concave.

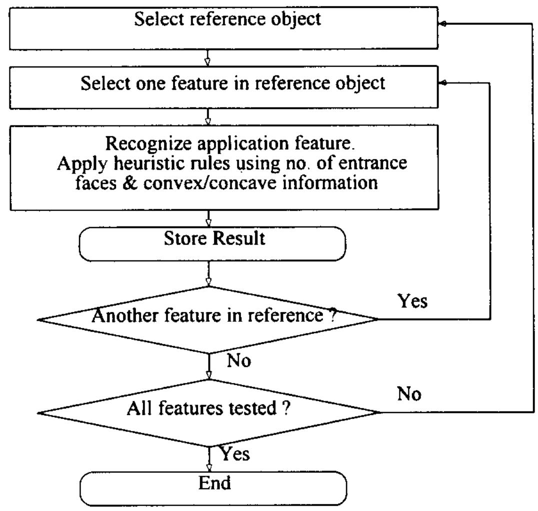


Figure 5 Algorithm for Feature Recognition

4 . Conclusions

In this paper, a feature recognition method is proposed to interface between geometric modeling and related applications. An example case is illustrated to recognize several depression volume shapes such as pocket, island, through hole, slot and step. Previous works on feature extraction using a cut node were generally limited to a single entrance faced feature, but this paper extends to multiple entrance face cases. The heuristic rules are used for feature recognition, and these rules can be extended to recognize various application specific features. The proposed method can be easily applied to design and manufacturing fields to obtain manufacturing information from computer-aided design(CAD) data.

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