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A note on the use of STEP for interfacing design to process planning

T. Dereli[a,*], H. Filiz[b]

[a]Department of Industrial Engineering, University of Gaziantep, 27310 Gaziantep, Turkey
[b]Department of Mechanical Engineering, University of Gaziantep, 27310 Gaziantep, Turkey

Abstract

This short note demonstrates the use of standard for exchange of product data (STEP) for interfacing *design* to *process planning* via a compact *feature recogniser*. The methodology used in development of the interface (feature recogniser) makes use of both automatic feature-recognition and feature-based design technologies in order to combine their advantages, and the STEP for the non-problematic and full information exchange. Using the abilities of the STEP, a generic configuration scheme is developed in which the features are treated as a combination of faces to which geometrical and/or technical information is glued (associated). By this way, the designer is only forced to identify the functional parts of the features when designing the part, which may simplify the component design and result in the effective memory utilisation. The feature recogniser was implemented in C on a PC and tested on a large number of examples with positive results.

Keywords: Standard for exchange of product data; Product data exchange; Feature recognition; Feature-based design; Process planning; Adjacency relationships

1. Introduction

Features are the fundamental elements of a product model. A feature is described as any geometric form that is used in one or more design/manufacturing activities, or it can be an information element representing a region of interest within a product [9]. Feature recognition is defined as the grouping of a set of faces on the surface of a part, such that each set corresponds to a feature. The recognition of features involves identification of higher-level features like pockets, holes, etc. from a set of lower level features such as surfaces, edges and vertices. The common methods that have been applied to the recognition of the features are syntactic pattern recognition, state transition diagrams, volume decomposition, set-theoretic or constructive solid geometry-based approach, graph-based approach, rule-based approach, neural-network-based approach, trace-based approach, etc.

The feature recognition work has several drawbacks as discussed in Ref. [10]. This is probably due to difficulty of representation of a generic object on a solid modeller, and due to increased complexity of the features on the prismatic parts. One of the obstacles to wide-spread use of the features and the development of better feature recognition systems is the low level of support for feature data exchange via standard for exchange of product data (STEP). On one hand, the application of many systems developed for the feature recognition of 3D has not been considered thoroughly enough to verify its suitability for process planning [5]. Four approaches to using features in CAD/CAM applications have been used in previous work; human-assisted feature recognition, automatic feature recognition, design by features (DBF; sometimes called *feature instancing*) and feature-based design (FBD). All of the four approaches used within the feature technology have their own benefits and hindrances. Therefore, it is profitable to find or to use a *mixed* (*hybrid*) *methodology* that makes use of the advantages of the approaches, while eliminating the drawbacks of individual systems.

In this paper, we have presented a feature recognition system, which is one of modules of an *in-house process planning system*. The input to the system is the STEP file created for a part which is modelled on any commercially available solid modelling environment. The part model is then translated from the STEP format into an equivalent format (structure) based on boundary representation (B-Rep) scheme that is accessible and manipulable in the application environment. Orientation of each face of the part is determined. Relationships between adjacent faces of the part are found based on 'concavity', and these relationships are stored in a 'relation matrix'.

* Corresponding author. Tel.: +90-342-360-1200x2601 ext; fax: +90-342-360-4383.
E-mail address: dereli@gantep.edu.tr (T. Dereli).

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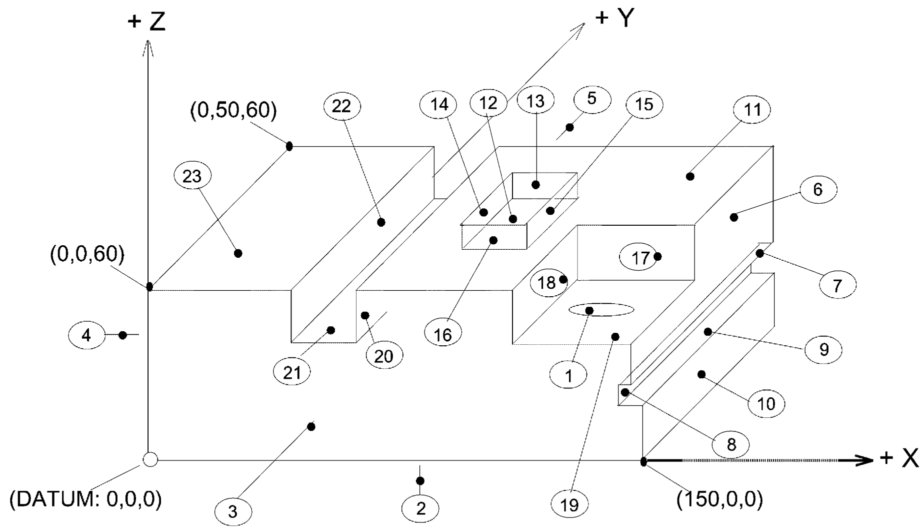

Fig. 1. A sample prismatic part for validation by Euler's law.

By tracing the elements of this matrix, part features are extracted. Then, they are identified and recognised by using a variable coding-scheme based on the numbers of faces, edges, etc. on the part features. The methodology of the developed system is illustrated with examples throughout the paper. It has an ultimate goal of underlining the importance of combining the advantages of existing approaches for the part representation, namely automatic feature recognition and FBD systems. Employing STEP for *full* and *non-problematic* information exchange between dissimilar CAD/CAM systems is strongly recommended.

2. Modelling, environments and problems

The transfer of data between dissimilar CAD, process planning and CAM systems is particularly important in today's *concurrent-engineering* work environments, where changes of widespread knowledge of design and manufacturing are critical. The STEP is the international standard for geometric and non-geometric data transfer between heterogeneous systems. It is sometimes also called *Standard for External Representation of Product Model Data*, also referred as ISO 10303, can be defined as 'a series of standards providing a platform or a mechanism that is designed for the standardisation and definition of all the processes and their parameters required to convert a CAD model to a product, independent of any of the design, application or manufacturing hardware and software or system' [4].

Many feature-based parametric CAD systems have become commercially available. They maintain a set of parameters describing features and a separate, but fully integrated B-Rep data model for the part. However, none of them has actually implemented a sufficient and generally accepted feature-based product representation for process planning applications. The information provided directly by those systems is not sufficient for process planning [3]. In this work, Pro/ENGINEER [6] is used as the CAD environment that serves as the front end of a CAD/CAM system. However, it is used only for constructing the model and other capabilities of the Pro/ENGINEER (except the Pro/STEP-INTERFACE module [7]) have been temporarily bypassed. With the Pro/STEP-INTERFACE module of the Pro/ENGINEER software, product data can be imported from and exported to any CAD/CAM system that supports the STEP.

3. Validation of the models

Validity of a polyhedral object based on B-Rep can be ensured by Euler's law. It states that a *polyhedron* is topologically valid if the following equation is satisfied:

$$F - E + V = 2 \tag{1}$$

where F, E and V are the number of faces, edges and vertices, respectively. This equation can be used for simple polyhedral objects like tetrahedron, cube, etc. without any passageways and holes. For example, a cube has six faces, 12 edges and 8 vertices. This satisfies Eq. (1). However, Eq. (1) cannot be used for those polyhedral objects with passageways and holes. For these objects, generalised version of Euler's formula is used:

$$F - E + V - L = 2(B - G) \tag{2}$$

where B is the number of bodies, G is the number of genuses like holes, and L is the number of inner loops to be found in the faces. It is worth to point out here that it is not so