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Intelligent system for extraction of product data from CADD models

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Abstract

This paper reports a system for automatic extraction of geometric and non-geometric part information from 'engineering drawings' created using computer-aided design and drafting (CADD) tools. A heuristic search is employed to interpret the characteristic attributes of dimension sets that denote linear, diametrical, radial and angular dimensions. Textual callouts are processed using natural language processing (NLP) techniques to interpret information related to part/feature function and related processes. The part information so recognized is represented using object oriented paradigm (OOP) suitable for linking to the downline CAD/CAM activities of the product cycle. The system, thus provides an effective alternative for design automation using CADD models. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Product model; Manufacturable features; OOP; NLP; Heuristic search

1. Introduction

The past decade has witnessed significant research on a variety of 3D part modeling techniques like constructive solid geometry (CSG), boundary representation (B-Rep), features technology, constraint-based modeling and of late the concept modeling. The primary objective has been to provide an informationally rich part representation scheme to support, if not all, a majority of business and manufacturing activities of the product cycle in an integrated manner [1,2].

Solid modeling schemes employing B-Rep and CSG form a core technology for part modeling as they provide a robust means of object construction, validation, manipulation and visualization. However, they lack explicit information in terms of functional features and non-geometric part attributes, which are very important in the down-line applications tasks [3]. Nevertheless, the current generations of CAD/CAM systems are based on these schemes.

To overcome these limitations, researchers developed feature supported representation schemes following two different strategies viz. feature extraction from solid models and feature-based modeling techniques. Several algorithms having a variety of capabilities have been proposed to extract and classify design and manufacturable features from B-Rep-based solid models. However, they lack ability to extract and represent non-geometric part attributes such as dimensions and tolerances, geometrical tolerances and specific information related to processes, tooling, etc. [4–8].

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An alternative strategy of feature-based modeling envisages a 'design by features' approach of model creation using functional feature libraries [9]. Here the features provide a means of representation of both geometric and non-geometric part data. Though this strategy is effective for specific part domains and related down-line activities like CAPP, DFM, DFA, etc. it lacks generality in terms of application [10,11].

On the other hand, industries typically use a large amount of part and assembly drawings for various engineering (design/manufacturing) and business activities [12]. To switch over to the CAD/CAM technology in the current scenario, industries will be required to model a large number of existing and new parts using solid/feature-based modelers. The effort involved in this activity will be labor intensive leading to larger lead times and costs.

In contrast, low cost computer-aided design and drafting (CADD) systems which provide 3D drafting (wireframe modeling) capabilities are quite popular in industries. These systems employ standard symbology for representation of diverse geometric as well as non-geometric part data relating to material, process and commercial functions. Though low cost and elegant, the CADD drawing models have a major limitation, in that they are suitable for human interpretation only.

A need therefore exists to develop algorithms for automatic interpretation of these CADD drawing models to extract and represent the relevant part/product information, for achieving the perceived design automation and CAD/CAM integration. This would establish an alternative route to the creation of informationally complete part model from CADD drawings.

This paper reports an intelligent interpreter for the extraction and representation of part information using a part model paradigm, from CADD models. Algorithms for extraction of part geometry and topology have been discussed at length in our earlier paper [13]. The present paper focuses on the recognition of non-geometric information for CADD models using NLP techniques.

2. Literature survey

Significant research has been reported on the automatic extraction of part features from B-Rep solid models using a variety of techniques like graph theory [4,14,8], syntactic pattern recognition [7,15–17], knowledge-based [6], etc. Parts with planar as well as non-planar surfaces have been analyzed to extract features. Though elegant, these algorithms are targeted towards the recognition of simple geometric features like generic classes of holes, pockets, bosses, etc. disregarding the non-geometric data like dimensions, size and geometric tolerances, process specific data, annotations, etc.

Works on feature extraction from 2D/3D wireframe models too suffer from similar limitations, in that most of them are capable of extracting only the geometry and topology of generic feature classes. Literature reports very few algorithms capable of recognizing non-geometric information from 2D/3D wireframe models though they contain a lot of information like size and geometric tolerances, and textual callouts pertaining to processes and other functions. However, significant work has been reported on various algorithms used in recognizing non-geometric data from scanned drawings. Some of the most relevant as far the work reported in this paper is concerned is discussed herein.

Probably, the earliest work was reported by Fitzgerald [18], for understanding dimensions of a graphical sketch for the purpose of rectifying and proportioning. It has the capability of analyzing the dimensions and suggesting over and under dimensioning. The aim was to provide a tool for conceptual design.

Pridmore and Joseph [19] proposed a system to convert scanned images to wireframe CAD models. Schema of drawing constructs and dimension sets are provided against which the extracted data is matched and classified. The classification is based on a set of rules provided by a parser. Joseph and Pridmore [20] further elaborated the strategy grammar used as control rules to recognize the dimension sets.

Dori [21,22] proposed a context free string grammar to recognize dimensions and size tolerances from scanned drawings. The grammar is extensive and is capable of interpreting linear, angular, diametrical and radial dimensions, but not the geometric tolerances or the textual callouts. The dimension nodes are partitioned into horizontal and vertical graph sets, which are further, analyzed using the graph theoretic approach.