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Using behavioral modeling technology to capture designer's intent

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Abstract

Ever since the introduction of geometric modeling technology in computer-aided design (CAD) systems, engineering designers have been able to speed up the design process and improve the design quality as well as collaborate on a design project with co-designers seated in different parts of the world. One of the recent emergences in the field of CAD tools is that of behavioral modeling (BM). It extends the capabilities of existing solid modeling applications by capturing the designer's knowledge in the computer model(s) of a design. It also assists the designer by iteratively checking model variances against designer specified constraints and goals so as to arrive at an optimum design during a reasonably short span of time. This article discusses the characteristics of its applications in a number of CAD systems. Some of the common characteristics include working within, or in conjunction with, 3D models and using behavioral features to embed design knowledge in a model. In the case of some high-end solid modelers, BM functionality has been combined with knowledge based engineering techniques.

Keywords: Behavioral modeling; Design intent; Design process; Computer-aided design

1. Introduction

In principle, computer-aided design (CAD) can be applied throughout the design process, but in practice its impact on the early stages, where very imprecise representations such as sketches were used extensively, has been limited. It is fair

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to state that most of the CAD systems did not help the designer in a more creative and intuitive way, such as the generation of possible design solutions, or in those aspects that involve complex reasoning about the design – for example in assessing by visual examination of drawings whether a component may be made, or whether it will fulfill the functions stipulated by the specifications. These aspects are, however, the subjects of considerable current research in the engineering design field.

Throughout the course of CAD development, the very first significant impact on CAD systems is believed to be the development of various methods for the representation of geometry using schemes that do not rely on projection into planar space. These schemes involve the construction of a single representation of the component geometry in three-dimensional space. Over the last 30 years, three types of 3D geometrical modeling schemes have been developed; they are in chronological order wire-frame, surface and solid modeling schemes. No doubt, the solid 3D modeling scheme leads to an "informationally complete" representation for any object hence permitting well-defined geometric property of any represented solid to be calculated automatically (Requicha & Boelcke, 1992). Many data structures have been proposed for solid modeling, of which two have been most prevalent and therefore have come to dominate the development of practical CAD systems. These are the boundary representation method – sometimes called B-rep for short, and the constructive solid geometry method – termed CSG or C-rep for short.

Thanks to these powerful geometric representation schemes, the contemporary CAD systems begin to provide new techniques that give the designer enhanced facilities to assist the design process as well as to increase the design quality. Behavioral modeling (BM) is one of the new tools in CAD systems. Its aim is to optimize and in some cases automate model creation. This has been done by embedding design knowledge into, or capturing designer's intent in, the geometric model, generally in the form of "features" (Allada, 2001). This design knowledge consists of specifications and goals which provide the basis for generating first feasible and then optimum models meeting design requirements. The BM tools leverage the standard model attributes (mass, surface area etc.) and combine them with inference engines to drive feature design. Additionally, external user defined applications can be linked to the behavioral modeler (and thus the solid modeler) to drive the optimization process. To this end, BM can be considered a type of artificial intelligence applied to solid modeling which animates an experienced designer's thinking pattern and reasoning behavior by way of constraint-based method to generate a design space of feasible solutions. Some applications have taken this to a higher level and implemented knowledge based engineering (KBE) solutions which allow automatic feature creation as part of a total product design process (McMahon & Browne, 1998).

This paper reviews the BM technology that is still relatively young, yet offering promises in engineering design fields. Several CAD systems with BM capability have been studied. It is also author's intention that much deserved attention is given to the technology by both the researchers and users.