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An Internet-enabled integrated system for co-design and concurrent engineering

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Abstract

In order to facilitate the product design and realisation processes, in this paper, an Internet-enabled system has been developed to support collaborative and concurrent engineering design by seamlessly integrating three functional modules, i.e., co-design, Web-based visualisation and manufacturing analysis, based on some state-of-the-art Java and Web technologies. In the co-design module, designers are equipped with co-modelling and co-modification facilities to carry out a design task collaboratively. The Web-based visualisation module provides a portal for users, who are not involved in the co-modelling process directly, to view and analyse a design part conveniently. Services in the manufacturing analysis module can be invoked by users dynamically to evaluate and optimise the manufacturing costs and the manufacturability of a design part so as to implement the concurrent engineering methodology during a co-design process. This system can be used for a design team geographically distributed to organise a 3D collaborative and concurrent engineering design effectively, and the proposed distributed and integration architectures enable the system to be generic, open and scalable.

Keywords: Co-design; Concurrent engineering; Web-based visualisation

1. Introduction

Manufacturing corporations have become more product-oriented, aiming at decreased lead times from design to manufacturing, minimal work-in-process, just-in-time flow of materials, and high efficiency and flexibility of manufacturing capacity utilisation. Recently, many philosophies have come into existence to facilitate the product design and realisation processes. Concurrent engineering (CE) is a systematic approach to integrate the design of products with related manufacturing processes using some software packages and computing techniques in a computer environment [1]. Within CE, a designer can consider and evaluate the downstream manufacturing processes of the product life-cycle in the initial design phase. Co-design is another increasingly important philosophy used in modern manufacturing corporations to collocate a multidisciplinary design team to carry out a complex design task through effective communication and collaboration. CE and co-design are complementary in functions since the former emphases a vertically seamless linkage between the upstream design and the downstream manufacturing processes through

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the creation of intelligent strategies for effective information interchange, while the latter focuses more on the horizontally interpersonal aspects of group work in the upstream design phases. With the trend for global competition and the rapid advances of the Internet technologies, both of them are moving towards supporting distributed applications, in which geographically dispersed users, systems and resources can be integrated in an Internet/Intranet environment beyond the traditional boundaries of physical and time zones.

In this paper, an Internet-based integrated system has been developed to support interrelated activities and share domain knowledge between designers and systems through integrating CE and collaborative design functions. This system consists of three primary modules: (1) a co-design module to enable designers to fulfill product design collaboratively; (2) a Web-based visualisation module to support product preview and evaluation of design parts; and (3) a manufacturing analysis module for designers to conduct CE methodology through invoking some distributed services. The system infrastructure and its distributed mechanism are built based on some Java and Web technologies, and high-performance communications among modules are maintained based on an event-based mechanism. The main advantages of this work include: (1) a convenient and flexible platform has been setup for users to carry out a co-design activity, with a scenario similar to the actual teamwork situation; and (2) a generic and scalable distributed mechanism has been proposed to integrate different functional modules in the system effectively to support CE, Web portal-based visualisation and co-design.

2. Recently related work

2.1. Co-design

The research and developments in co-design are active and a number of software tools and methodologies have been developed in this area. The appeared work can be generally categorised into two types from the perspectives of collaborative strategies and functions: (1) visualisation tools to assist co-design, and (2) co-modelling tools to implement co-design.

The work in the first category is primarily used to support visualisation, annotation and inspection of design models in a Web or a CAD environment. Commercial systems include Autovue™ [2], ConceptWorks™ [3], eDrawings™ [4], Streamline™ [5], etc. The Web-based systems are light-weight, easy-deployed and platform-independent, and they can facilitate an on-line team to take on high-level product review, customer survey for new products and conceptual design. Java Applet and MS ActiveX technologies are widely used for developing the visualisation clients, while some services written in Java Servlet or MS COM/DCOM technologies are deployed in the server side to provide support and system maintenance [6–8]. In order to deliver and manipulate interactive 3D objects effectively in the Web, some concise 3D formats for Web applications, such as VRML, X3D and MPEG-4, have been launched to represent the geometry of 3D CAD models as visualisation-used triangular meshes and trimming lines [9]. Most of the current CAD systems are equipped with an export function to convert a native model to a concise 3D model for Web applications (e.g., VRML). However, during the conversion process, the information for the high-level design features, which are quite important in CAD systems to encapsulate design intents, is lost. Due to this limitation, most of the visualisation systems can only provide viewing and mark-up functions, and they cannot effectively support some on-line manipulation operations on features such as highlighting or hiding a feature and its properties in a design part.

Real co-design with co-modelling functions can be supported by the second category, and several popular systems are Alibre Design™ [10], OneSpace™ [11] and CollabCAD™ [12]. Co-modelling systems usually consist of four kinds of components—team management, distributed part and assembly modeller, repository and messaging. In the team management component, collaborative mechanism and team organism principles are specified. The distributed part and assembly modeller is used to establish a workspace to effectively share and distribute detailed design models among a working team. The repository can store and manage design parts and related information. The messaging component can support several popular messaging services such chatting, discussion forum and whiteboard among designers participating in a