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A Web-based service for distributed process planning optimization

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Abstract

The advance and pervasive applications of the Web-enabled computations are exerting a profound influence on product design and manufacturing processes, and one of the major technical shifts for product development systems is toward supporting distributed collaboration. A key component for this trend is to develop a service model that enables product development systems to be triggered and manipulated from a remote computer, so as to provide a more flexible manner to share and interoperate the executive codes and processing data. In this paper, a process planning optimization module has been wrapped as a Web-enabled service and deployed in the Internet to support distributed design and manufacturing analysis. The module consists of several optimization approaches, and a Tabu search-based approach, which can optimize the selection of machining resources, determination of set-up plans and sequencing of machining operations to achieve optimal process plans, is elaborated to illustrate the process. The Web-based service has been integrated with a distributed feature-based design system, and the latter can generate design models and re-represent them in an XML representation based on VRML and attributes of features to provide the input of the former. Through effective utilization of the Web and Java technologies, the established service and relevant system can be used by a distributed design team to organize concurrent engineering activities effectively.

Keywords: Process planning; Web-based system; Distributed product development

1. Introduction

Global competition offers sufficient return on investment only to those who can provide innovative products first to the market. In order to develop a complex product with higher quality, less development iterations and more cost competitiveness, an effective practice used in many manufacturing companies in the past decades is to collocate a multi-disciplinary design team, which usually includes research and design engineers, manufacturing engineers and marketing staff, in close physical proximity. Presently, as the global competition and the rapid advances of the Internet technologies, the paradigm of the design activity is changing dramatically, and the structures of design teams for developing products are extended from a hierarchical organization within a company to a

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distributed organization across companies. Future design systems are moving towards supporting distributed and collaborative activities, in which geographically dispersed designers, systems and resources can be integrated in an Internet/Intranet environment and a virtual design team across the traditional boundaries of physical and time zones can be set up.

As one of the most popular Internet tools, the Web aims to provide a light-weight, easy-deployed and platform-independent means for users to search, browse, and retrieve information disseminated and shared remotely. Based on the Web, design models can be dynamically shared and updated in an Internet environment and conveniently accessed and manipulated by remotely located people from the design team, management, marketing, maintenance and customers for efficient design collaboration, design process monitoring, product pre-review and evaluation. Application services in product design, process planning, engineering analysis and simulation, can be conveniently embedded in a Web environment as Application Service Providers (ASPs) for remote invoking and manipulation. Realizing the merits of the Web technology, researchers and developers have been actively exploring and developing Web-based design and manufacturing systems, and the work can be summarized from the following two aspects.

1.1. Web-based visualization systems

Web-based visualization systems (Cimmetry Systems Autovue™, www.cimmetry.com; Actify SpinFire™, www.actify.com; Adaptive Media Envision3D™, www.adaptivemedia.com; Autodesk Streamline™, www.autodesk.com/streamline-trial) have been developed to support visualization, annotation and inspection of design models to provide assistance of distributed design and manufacturing activities. These visualization systems are light-weight, easily-deployed and platform-independent, and they can facilitate an on-line team to take on design review, discussion, remark, customer survey to enhance collaborative product design and analysis. In order to deliver and manipulate interactive 3D objects effectively on the Web, some concise formats specially designed for Web applications, such as VRML, X3D (www.web3d.org/x3d), W3D (www.macromedia.com) and MPEG-4, have been launched to represent the geometry of 3D models as visualization-used triangular meshes, trimming lines and some attributes (Web3D Consortium, www.web3d.org; [18,8,10,24]). VRML is fundamental for the series of the standards to represent geometric elements and scenes, while X3D and MPEG-4 are extended to support XML-based representation and video/audio application in compressed binary formats, respectively. Some formats such as OpenHSF (Hoops™, www.openhsf.org) and XGL/ZGL (Autodesk Streamline™, www.autodesk.com/streamline-trial) are functionally equivalent to VRML in geometric representation while they define data and algorithms for effective 3D streaming transmission over the Internet through data compression, mesh simplification and object prioritizing.

The Web-based systems are based on the HTTP communication protocol, and there are two basic means of programming, i.e., server-side programming and client-side programming [18,8,10,26]. For example, Java Servlet, Microsoft ASP[1] and CGI, which belong to the first means, can execute codes at the server-side to generate display information at a Web browser (client), and Java Applet and Microsoft ActiveX, which are examples of the second means, need to download codes from the server and execute them at a Web browser. Considering the large-volume 3D data and frequent requirements for interactive operations, hybrid architectures are mostly designed in which the client-side programming is used to support the establishment of the visualization systems embedded in a Web browser and the server-side programming is to maintain the information communication between clients and a server. As Java programming Application Programming Interfaces (APIs) for light-weight 2D and 3D models (such as VRML models), Java2D and 3D have been popularly used to run in a Web browser for graphics rendering and manipulations.

1.2. Web-based design and manufacturing systems

Due to the diversified functions and applications, the reported works in this category have different characteristics and implementation strategies. How-

[1] This ASP is different from the ASPs mentioned earlier. The former is a programming technology and the latter is an application and business model. The ASP(s) in the following part of the paper refers to the latter unless specified.