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STEP-based product modeling system for remote collaborative reverse engineering

R.S. Lee[a,*], J.P. Tsai[b], Y.C. Kao[c], Grier C.I. Lin[d], K.C. Fan[e]

[a] Department of Mechanical Engineering, National Cheng Kung University, Tainan 701, Taiwan, ROC
[b] Center for Virtual Design, Far East College, Tainan County 744, Taiwan, ROC
[c] Department of Mechanical Engineering, National Kaohsiung University of Applied Sciences, Kaohsiung 807, Taiwan, ROC
[d] Center for Advanced Manufacturing Research, University of South Australia, Mawson Lakes SA 5095, Australia
[e] Department of Mechanical Engineering, National Taiwan University, Taipei 106, Taiwan, ROC

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Abstract

Production of high-quality products with lower cost and shorter time-to-market is an important challenge in the face of increased global competition, and reverse engineering plays an important role in accelerating product and process development. With the advent of new technologies such as network, multimedia and product data exchange standard STEP (STandard for Exchange of Product model data), there are many advantages to adopt these technologies to enhance the competitiveness of an enterprise. In this paper, a product information recording module for reverse engineering is developed to enhance the performance of product development. A STEP development tool, ST-Developer, and Visual C++ were used to develop this module, which can be used to record key information expeditiously during a collaborative process, and can also be used for further exchange of information, or as the basis for manufacturability evaluation. In this paper, the developed STEP-based information recording system is further integrated with the conventional Computer Supported Cooperative Work (CSCW) methods such as videoconferencing and application-sharing to form a remote collaborative reverse engineering system, which can provides a new strategy for an enterprise to speed up the product development cycle, reducing production cost, as well as sharing knowledge and experience.

Keywords: STandard for Exchange of Product model data; Collaborative engineering; Reverse engineering

1. Introduction

Product and process development is a very complicated engineering process with strong interactions among its development tasks, and requires iterative discussion to communicate and coordinate the re-design process. Recently, the concept of concurrent engineering together with integrated product and process development has been frequently discussed. The essence of this concurrent product and process development is an integrated and collaborative process, where people in different disciplines cooperate to specify and design products and their processes, for which coordination, communication, and negotiation are required. To achieve this, Lee et al. [1] integrated knowledge, geometry and data to develop a concurrent mold design system. Since new product and process developments require simultaneous incorporation of a wide variety of design and manufacturing expertise, concurrent engineering using new multimedia and network techniques will be a feasible solution to integrate experts who work at locations worldwide.

In recent years, reverse engineering has played an important role in accelerating product and process development; and there have been many studies on this topic [2–5]. Although most of them have focused on the technology of surface reconstruction and scanned data reduction, it is necessary to develop a STandard for Exchange of Product model data (STEP)-based information recording module to store and transform the knowledge during the reverse engineering processes. This paper combines product data modeling, the concept of concurrent engineering and Computer Supported Cooperative Work (CSCW) technologies to

*Corresponding author. Tel.: +886-6-2757575; fax: +886-6-2352973.
E-mail address: mersl@mail.ncku.edu.tw (R.S. Lee).

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develop a rational, extensive and rapid collaborative reverse engineering system to speed up and to improve product and process development.

Recently, there have been numerous efforts on STEP research, such as surface data definition, metrology planning for contact coordinate measure machine (CMM), engineering data management (EDM), etc. Vergesst [6] studied the geometrical aspects of STEP, especially on B-spline curve and surface. Lin and Chow [7] researched the resources and constraints of contacted CMM and defined their EXPRESS data. Peng and Trappey [8] developed an integrated product database for EDM based on Parts 41–44 of their integrated resource model. As reverse engineering has become more important in speeding product and process development, it is necessary to research STEP-based reverse engineering information. In this paper, a STEP-based product modeling system for remote collaborative reverse engineering has been developed. This system focuses on non-contact CMM (scanner), and the related product and process information is systematically studied.

A series of research efforts has been focused on CSCW since the 1980s and has been shown to be able to support collaborative work effectively. Most of these researches focused on resolving the collaboration issues arisen from time and place differences through the assistance of videoconference, application-sharing systems and some other multimedia tools to ease the collaborative work. However, it seems that the history information on the product data during the collaborative reverse engineering session has not been tackled through the application of STEP yet. Generally, there are four categories [9], as shown in Table 1, in the CSCW issues: (1) same time and same place, (2) different time and same place, (3) same time and different place, and (4) different time and different place. This paper has been focused on the third category "same time and different place". The objective of this paper is to develop STEP-based information recording system integrating conventional CSCW tools, such as videoconferencing and application-sharing, to form a remote collaborative reverse engineering system.

Table 1
Research focus on CSCW methods in this paper (2×2 Johansen's time–place matrix [9])

Place	Time	
	Same	Different
Same	Meeting environments	Team work Work shifts
Different	Tele-, Video-, Desktop-Conferencing	Electronic mail Computer conferences Collaborative writing Workflow management

2. System analysis

The conventional reverse engineering process involving many iterative activities for design change is shown in Fig. 1. In contrast, this paper proposes a new methodology to integrate expertise in order to collaboratively discuss and provide timely decision-making to shorten the process cycle. Fig. 2 shows the IDEF0 system analysis model, which is based on remote collaborative reverse engineering metrology. Using the synergy of the IDEF0 structural analysis model and the CSCW strategy, the concept and objectives of a remote collaborative reverse engineering system can be clearly seen. The characteristics of product and process development with remote collaborative reverse engineering, including the activities and tasks involved, their constraints, and supporting resources, as well as information flow in the process can be clearly described. The activities of product and process development with reverse engineering in this paper are divided into (1) metrology planning, (2) digitized data processing, and (3) surface reconstruction and modification.

To concisely describe the contents of cooperative work in this system of remote collaborative reverse engineering, Fig. 3 illustrates the engineering processes, communication methods, and the STEP-based product engineering information recording module, which can be used to record the key information in CSCW process such as videoconferencing or application-sharing. For instance, the maximum error or curvature of the fitting

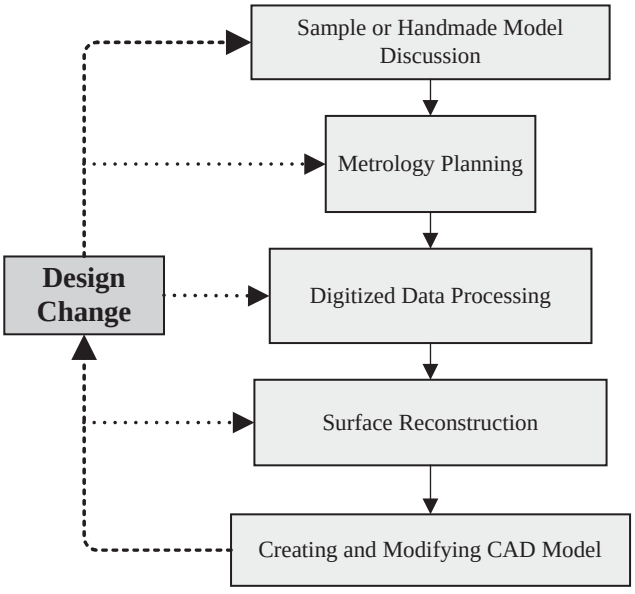

Fig. 1. Conventional reverse engineering system process.