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An online Web-based environment for detailed design reuse

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Abstract This research presents an online Web-based environment for the reuse of detailed design. In this environment, users can browse existing product databases including all related product information and graphic displays of the geometrical models, search and retrieve related products and generate new designs from existing products. In the underlying database, product data are clustered into product families to facilitate data management and reuse, and the variant method is adopted to transform an existing design into a new design.

Keywords Design reuse · Detailed design · Online environment · Product design · Product family · Variant method

1 Introduction

Designreue is a practice that almost always accompanies product design. It is estimated that 90% of all industrial designs are adaptive or variant [1]. This means most of the design problems are solved by making use of existing designs in some way rather than being designed from scratch. Design reuse is vital to reducing development costs and lead-time while maintaining stable design quality in an ever-changing and highly competitive market.

Design reuse happens in many ways. The design problem-solving process consists of four phases [2]: problem clarification, conceptual design, embodiment design and detailed design; the form and substance of design reuse at different stages vary respectively. Detailed design is the final and output stage of the design process. Hence, design reuse activities will influence the reuse of detailed design. Research on detailed design reuse is therefore of great importance, and forms the foundation for design reuse in other phases.

Since the detailed design phase is so far the most explicitly understood and computerised phase in the design process compared with other phases like conceptual design or embodiment design, much more effort has been devoted to this area, and many prototype systems have been developed. Related research issues include detailed design data-storing methods [3, 4], database construction [3, 5], related feature-extraction techniques and geometrical data similarity evaluation [5], development of standard languages for detailed design description and product modelling [6], functionality capturing of detailed design data [3, 7] and finding appropriate methods to retrieve detailed design data [8]. These efforts, to some extent, embody Duffy’s design-reuse-model [9]; namely, design-by-reuse, design-for-reuse and domain-exploration. For example, functionality-capturing of detailed design data, which is conducted during product design, is a form of design-for-reuse, and the functionality recorded can be used as a searching index for product data retrieval; design description languages and the methods for storing and for database construction are designed to facilitate product representation, recognition, information extraction and retrieval, which are issues falling into the scope of domain exploration.

Despite progress in this area, most of these researches and many of the prototype systems are implemented on a single computer or workstation as a standalone system based on a certain solid modeller [10, 11]. However, the design realisation process has become more and more globalised and distributed, and other product development life-cycle activities like marketing, manufacturing, etc., have become tightly interwoven with design [12]. Under these circumstances, a standalone system obviously cannot fulfil this need, and an open environment that can be easily accessed to assist product design by reusing previous design is of great importance and benefit. It will greatly promote the understanding and utilisation of previous designs, as well as the evolution of new design.

The rapid development of information and Internet technologies provides a suitable infrastructure and techniques for the development of such design environments. The Web-based online environment for detailed design reuse presented in this paper allows user to reuse previous detailed design data by visiting the online servers via the Internet from anywhere without the need to directly handle the 3D geometrical data with a specific CAD...
system. In this environment, users can browse previous designs, search for relevant designs and create new designs based on them.

The Web-based environment is made up of two server programs – an HTTP server and a UG/Open API server program in a UNIX host. The two server programs communicate via the Internet. In this environment, all product data are clustered into product families based on their functions and geometrical similarity to facilitate data management. In addition, the variant method is adopted to generate a new design from an existing detailed design.

In the present paper, Sect. 2 gives a general description of the architecture and the operation of the Web-based design environment that has been developed in this research. Section 3 provides some related background on product family, variant methods and feature-parametric-based modelling. Section 4 presents a detailed explanation of specific operations on the environment. Finally, the conclusion is presented in Sect. 6.

## 2 System architecture

As shown in Fig. 1, as with all other online service systems, users can just access and interact with the HTTP server in this design reuse environment using the common Internet Explorer. All users’ requests relating to product geometrical data will be diverted to the UG/API server program. Like all online service programs, data management is an indispensable component. In this system, there are two kinds of data – one is text-based product information data, and the other is geometrical data. The former is stored in a relational database and is called and processed by the HTTP server program, while the latter is stored in the form of UG part files residing on an online UNIX host.

### 2.1 HTTP server program

There are three main functions for the HTTP server program; namely, product data browsing, product searching and retrieving, and communication with the UG/API server program. These three functions are briefly described next.

**Product data browsing.** Users can browse the hierarchical structure of the complete design database. At the same, users can also view the detailed description of any specific design with a graphical display.

**Product searching and retrieving.** The server program takes in the users’ design input, such as the functional requirements or other searching criteria, and searches the design database to retrieve the most approximate ones to reuse.

**Communication with the UG/API server program.** Users’ requests relating to geometrical data processing will be sent to the UG/API server program via the Internet socket communication. Next, the HTTP server program will receive feedback from the UG/API server program to answer the users’ requests.

### 2.2 UG/API server program

The two main functions of the UG/API server program are detailed design reuse and graphical file generation.

**Detailed design reuse.** The UG/API programs are capable of generating new detailed designs from existing design data based on the variant method.

**Graphical file generation.** Currently, due to the bandwidth bottleneck of the Internet, it is still not viable to display original CAD data files, such as UG part files in this system through the Internet. However for product design, graphical displays are vital for understanding. Hence, in this system, the virtual reality modelling language (VRML) file format is adopted for online graphical displays. Each time a user browses certain design data or tries to reuse it, the UG/API server program will instantly generate an up-to-date VRML format file of the design and send it to the HTTP server for display.

### 2.3 Design descriptions and data structure

In the present online Web-based system, the description of a specific product design consists of two parts – product attributes and a geometrical model. The product attributes include functions, key characteristics, cost, etc. They are all text-based, and are stored in a relational database. As for the geometrical models, all 3D models are stored in the UG part file format and reside on an online UNIX host.

## 3 Background

Before going further to describe the specific operations in the design reuse environment, some background methods are presented in the next section, and their applications to the online Web-based system are addressed.

### 3.1 Feature-based parametric modelling

This is the most widely used modelling method in mainstream solid modellers. It is a combination of the feature-based and parametric-based modelling methods [6, 13]. In feature-based modelling, a solid model is constructed by combining features