Development of Internet CAD System for CE Environment

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Abstract

As the rate of globalization increases rapidly, Internet technology is playing a more important role in many fields. Considering the design process, a new way of designing, which is interactive and intelligent, can be introduced. Therefore, this paper presents an intelligent computer aided design (CAD) system which integrates Internet power and artificial intelligence techniques to support the intelligent design system for concurrent engineering environment. The practical application proposed emphasizes a customer driven product with high inventory cost - gold chain manufacturing.

1. Introduction

Due to the situation of global competition, quality and price of products are no longer the only two factors required by customers. A quick response in launching the products to the market has become another prime factor to satisfy customers. The effort to compress the time required in the development of the design and production processes has given rise to the concept of Concurrent Engineering (CE).

When considering the concept of Concurrent Engineering with reference to design activities, concurrent engineering concepts synthesize five basic principles : system thinking, continual improvement, empowerment, inclusion, and rectification. Commonly agreed as belonging to the design process, Concurrent Engineering represents a new form of manufacturing technology. Being different from the traditional way, it focuses on parallel processing through combinations of various engineering activities.

Although the prosperous growth of computer technology has enhanced and eased the work-load in the design stage to a great extent by the utilization of conventional CAD software, the lead-time of the conceptual design stage has not considerably reduced. It still represents the most time consuming stage and drags down the overall performance of the product development team. Consequently, a new generation of CAD software has been proposed to facilitate the activities in the conceptual design. Besides the implementation of CE concept to shorten the development time, this new CAD system has to be intelligent in assisting the designer in making evaluations of alternatives, provide a real-time interaction between the designer and customers and occupy a user-friendly graphic environment. Therefore, there is a need to develop an intelligent CAD system, which can be interfaced easily with customers around the world through the Internet, providing intelligent assistance to the designer.

The concept of concurrent Engineering can be applied to CAD/CAM program, by developing computer packages which have the ability to integrate all related engineering activities and to develop a real-time user-friendly computer interface. The implementation of concurrent engineering provides a number of benefits which enable a firm to gain the competitive edge. The main result is to achieve higher quality and shorter lead time.

2.Problem Statement

Although there are many commercial CAD packages on the market, some even claiming that they still lack many factors such as cooperation between different parts of the manufacturing process. There is a need to link design development to the manufacturing process. The CAD package must include guidance on how to avoid possible downstream problems caused by the initial design.

The design and knowledge base encompass very broad area but they can be narrowed down. Therefore this paper aimes to develop an intelligent CAD system for gold chain manufacturing because the raw material, gold, is costly and reproduction of the products results in costly losses of material.

In addition, gold chains are customer oriented and thus it is necessary to keep up with customer needs during the design stage. Moreover there are many manufacturing constraints and some custom-made designs are difficult to produce cost-effectively.

The difficulty lies in the acquisition of expertise knowledge related to the product and production process. Moreover, the executed algorithm of the computer program is required to be generated in such a way that both qualitative and quantitative values can be handled simultaneously in order to obtain an optimized evaluation. By bridging all the mentioned gaps, a proper method of how to integrate the artificial intelligence approach and concurrent engineering concepts with CAD software needs to be determined.

To identify the direction for the development of a general design tool covering concurrently the aspects of design activities, especially the critical conceptual design part, problems occurring in the conventional CAD system first need to be addressed [1,4]. There problems are: (1) Conventional CAD systems are not complete in design process development and some do not support the conceptual design; (2) Intelligence in assisting the designer in problem-solving is not present; (3) The new CAD systems should have the capability of design object information concurrently; (4) The user interface of conventional CAD systems is insufficient. New facilities to understand the functional purpose of the designer's input should be provided to translate the input data with an adapted format for computers such as IGES format; (5) Error check is not available. Mistakes in data input and knowledge selection generate contradictions in later design. Contradiction resolution facilities at both the knowledge-based level and database level have to be implemented.

To solve these problems, the future CAD system requires the following specifications:

1. The system has to support the designer in all design stages with intelligence, especially with the expert knowledge of the previous design by covering the understanding of the designer's intent, verifying and validating designs, suggesting alternatives, and storing the expert designer's knowledge for future use.
2. The system has to reduce the overall time and cost of the design activities.
3. There must be a Link between the process and production facilities of the manufacturing environment.
4. The system needs to respond in real time to cope with the changing marker.

Concerning the aforementioned considerations, the development of the new CAD system, namely **Real-time Intelligent Knowledge-based Computer Aided Design (RIK CAD),** was initiated. The objective of this project is to develop a model to integrate the artificial intelligence and computer aided design software with the emphasis on concurrent engineering as the core. A user interface module through the Internet is attempted to be included in the development to improve the flexibility and the presentation of the design object in a user-friendly manner. The problem-solving ability is strengthened through the search of possible methods to integrate the expert system into the design phase. This synergistic relationship enables the designer to respond to real situations effectively and efficiently as a remedy to a concurrent engineering management problem: how to develop a computer aided engineering design that acquires both the heuristic expertise decision and knowledge to facilitate the design, evaluate the manufacturability, and select the optimized designs.

3. Development of RIK CAD

Despite providing feedback to the product design explicitly, the feedback and decision-supporting systems are represented in the form of an expert systems integrated into the CAD environment [1], [2] and [3]. To deal with the problem of the selection of combination of different elements, the basic catalogue selection method [4] is applied to allow the user to

determine the best trade-off between the use of resources during the design process and the "quality" or "utility" of the final design produced. Finally, in the expert system structure, the steps in integrating the end-user preferences for design evaluation [5] are adopted. For developing an expert system, the rule-based design selection concept [6] and the object-oriented design generation concept [7] are adopted. There have been successful applications with the decision support system application at Hong Kong jewelry industries [8].

Regarding the Internet which is concerned with the design topic, the driven forces that make the Internet and the world wide web take a role in the engineering field are the characteristics of the web itself. Some of these capabilities are universal addressing, the availability of a common interface, platform independence, and the impact of the mass-market demand for the technology. This means that many problems that engineers have to face today can be solved using the web, such as an internet factory which can solve mathematically difficult problems within a short period by using parallel computing concept through internet facilities.

Therefore, the concept of concurrent engineering (parallel implementing) engineering is implemented as a core and is used to develop a prototype of **Real-time Intelligent Knowledge-based Computer Aided Design (RIK CAD)** package. The development of RIK CAD system is based on the circumstance of make-to-order strategy where the customer and the actual designer of the product interfaces with the computer and implicitly transfers his functional requirements interactively as the software systematically translates the requirements into design specifications and checks for manufacturing feasibility of the proposed design before production of the designed product.

The structure of the RIK CAD system is primarily composed of the integration of expert system and CAD system. Because of its object-oriented programming (OOP) capabilities and Java programming language compatibility, Java Expert System Shell (JESS) is used to generate the knowledge base of the RIK CAD expert system. JESS is a clone of the popular CLIPS expert system shell written entirely in Java. With JESS, the Java applet can have the ability to reason. Considering the Computer Aided Design software, AutoCAD software is selected due to the effectiveness of the drawing and design tools available to the drawing professional. The key underlying benefit to the user has always been the ready access to utilize their own embedded programming language, AutoLISP. In order to improve the communication between the designer and the customer so as to be in prompt interactive conformation, the concept of internet communication is introduced. Therefore, to handle this world-wide interaction, this intelligent CAD system is designed to operate under Java interface.

In spite of the fact that Java programming language has a strong capability in Internet programming, some restrictions occur due to the security concerns. The most important restrictions are that the Java applet is unable to interact directly to the user storage space and cannot execute other applications by itself. Consequently, the concept of server-client development is introduced. By using this approach, more encumbrances will be on server-side than client-side. Therefore, to create communication between server and client successfully, Java servlet is selected and is instrumental.

A Java servlet is a server-side module that is platform and protocol independent. Servlets can be used to extend the functionality of a Java-enabled Web Server. Although the concept of using a servlet is the same as the concept of Common Gateway Interface (CGI) which is widely used by many existing web sites, many aspects are considered to be more powerful than CGI. For example, platform independence, ability to encounter network programming, ability to reuse, higher performance, etc.

Furthermore, to accomplish the objective of the project, the software has to have the ability to integrate CAD applications. To achieve this, the Java interface needs to manipulate the Native methods. The Native methods are the situations where a Java programmer can write/use code written in another language and then call this code from Java. Due to its powerful capability in depth, the C++ programming language is selected to be the native code. This C++ code will use the Child process to execute the CAD software and send the result back to the user on the client-side.

Referring to the server-client development, server administrative software is required. Due to the capability to handle the Java servlet, the Java Web Server 1.0.3 is selected.

4. RIK CAD Architecture

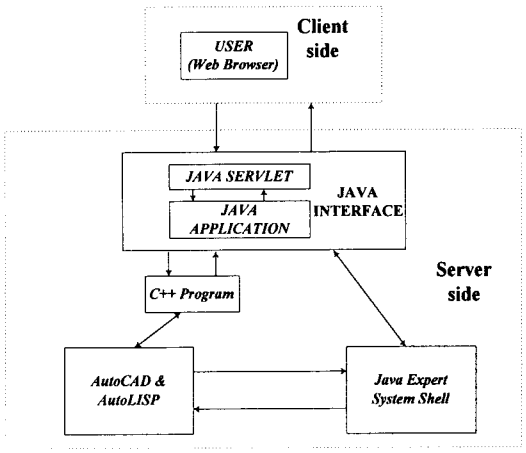

Figure 1. Structural Architecture of RIK CAD

Based on a study of the design process, design objects, and design knowledge, the framework of the RIK CAD system can be categorized into two main classifications: Client-side and Server-side. Figure 1 shows the general structure of the RIK CAD system. The client-side or, in other words the user-side is directly concerned with all of the user's activities by using a web browser as the tool for navigating the software.

Considering the server side, it consists of 4 main components: Java interface, C++ Program, CAD software, and Java Expert System Shell (JESS). Moreover, the Java interface can be classified into 2 subparts: Java Servlet and Java Application.

The first step in implementing RIK CAD software is a request from the user for the web page. This web page will allow the user to primitively design the products attributes and specifications by himself. After finishing the design process, all of the necessary parameters will be sent to the Java servlet on the server side. Servlets are used to facilitate the communication between the server and client. Subsequently, the servlet will automatically invoke Java Application and pass the information to the application. The Java Application is a stand-alone program, which has the ability to use the Native methods. By using Native methods, the Java program will be enabled to execute Native code program such as C or C++ code. The RIK CAD software requires C++ program to execute the AutoCAD software in generating the designed drawing. The child process will be operated by C++ language in executing the CAD software. The CAD software will generate the drawing and convert it into the Bitmap File type and send it back to the client by the same route.

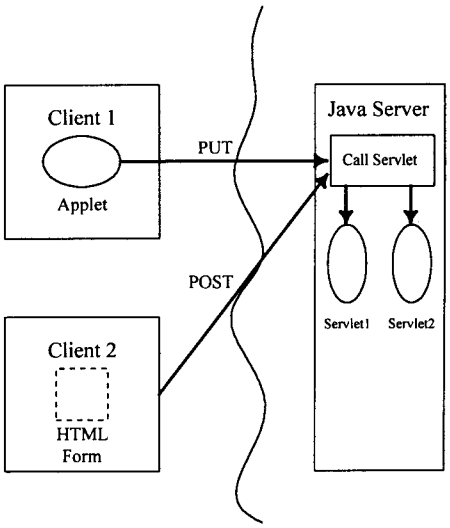

Figure 2. Java Servlet Application Procedure

At the same time, the expert system is invoked automatically as a consequence of some actions or decisions of the designer. The real-time interference engine executes the rule base. In order to fulfil the condition of the rules, the interference engine requires data. These data are obtained in the following hierarchical order.

(a) If the required data are primitively contained in the expert database or CAD database, these data are used to satisfy the rules.
(b) If the required data are not contained in the current relational databases, the inference engine asks the user for required data.

When all the data needed to satisfy the rule base and to reach a feasible conclusion are

available to the inference engine from either CAD database or the expert system database, no questions will be asked of the designer, who simply sees the final design object displayed on the screen. On the other hand, when the design is not feasible, the user is asked for modification of the design requirement. This process continues until a conclusion is reached.

5. Case Study

Although, the concept of RIK CAD can be applied to a variety of design processes, this paper is concerned only with gold chain design. The purposes of using gold chain manufacturing as the case study are as follows:

(a) Gold manufacturing process has a high inventory cost. Therefore, using the concept of RIK CAD can reduce the time used for designing and producing the product, which will reduce the inventory cost at the same time.
(b) Gold design changes according to fashion. The application of RIK CAD allows the gold manufacturer to act promptly to change in customer requirements.

Due to fluctuations in the cost of gold, the shorter the design time, the more saving for the gold chain manufacturer. Customer characteristics in buying a product nowadays differ from the past. They want something uniquely designed for an individual so as to differentiate oneself from others. The patterns of gold chain designs are important information for the manufacturer, these can be obtained by the use of RIK CAD software.

To achieve a consecutive project, the development of the method of approach has to be scrupulously considered. Hence, classification of the procedure is required to be arranged.

5.1 Java Interface Development

Java programming language is a significant tool in interfacing the RIK CAD software. The foremost development is the construction of the Java Servlet to facilitate the communication between server side and client side. The concept of servlet is the same as the concept of Common Gateway Interface (CGI) except using Java programming language instead of C or Pearl language.

To create the servlet, the Java Servlet development kit (JSDK) is required. At the moment, JSDK is in version 1.0.1 and will be continuously improved. Became the Java servlet is run under Java-enabled server, the Java Web Server 1.0.3 has to be introduced.

Since servlets run inside servers, they do not need a graphical user interface. Otherwise, they are the server side counterpart to applets: they are Java application components, which are downloaded, on demand, to the part of the system which needs them. Figure 2 shows the general concept of Java servlet application procedure.

In implementing the concept of servlet with RIK CAD software, the servlets have to have the ability to receive the information in HTML form. These data include the formation of gold chain, the purity of gold (in percent), the weight of gold per chain, the length of gold chain, and numbers of rings per chain. All of this required information will be passed to the Java application program, which will process them through the procedure.

In communicating between the web page and the servlet, POST method provided by JAVA servlet was chosen. This is due to its widespread usage based on the standardized application. The developed web page will present the pictures of gold rings and allow the user to create their own chain. After finishing the pattern, the user is requested to specify the required information.

The next step in developing the Java interface is the elaborating of the Java Application by using Native Method as the developmental technique. This Java-Native Method code will have the ability to link to platform-specific native code. In this project, C++ language is selected to be the native code.

Referring to this project, there are some special circumstances when native methods may be an appropriate solution for Java software development. The controlling factor is the Java security concern, which does not allow the Java program to execute other programs by itself. Therefore, C++ program is required to execute the AutoCAD program.

This Java application will receive the required specifications including Pattern of gold chain, the purity of gold (in percent), the weight of gold per chain, and number of links, from the servlets and send these specifications to C++ program. The C++ program will automatically evoke the AutoLISP and transfer the pattern of gold chain to LISP program.

5.2 Primitive Parts Development

Preliminary, the parts were generated automatically based on the genetic algorithms approach. The basic primitive parts shapes such as circle, rectangle, ellipse were developed inside the AutoCAD package using AutoLISP programs. Then, alternative part shapes were generated based on the combination of those primitive parts. For example, the combination of primitive part shape –rectangle derives the rectangle block in 3D. It is illustrated in figure 3.

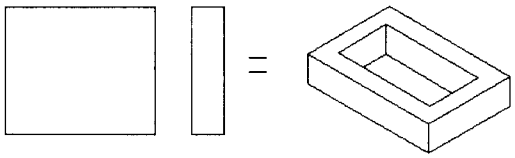

Figure 3 – Automatic Development of Parts

Based on automatic part development concept, the primitive parts for gold rings are developed and kept inside the product database. This is shown in figure 4.

The customer of this on-line gold chain manufacturer just works with the Java interface to select the type and the arrangement of the gold chain. Soon afterwards, the selective parameters of the customer will be passed from Java interface to AutoLISP. At this time the AutoLISP will be invoked and receive the necessary value to execute the procedure. Finally, the finished design of the gold ring will be sent back to the Java interface again. Therefore, 18 primitive parts were created in the form of an AutoCAD drawing. Furthermore, to include all of the drawing in a web page, the Bitmap file conversion was required. In addition, to make the software complete, the AutoLISP program has to be developed to receive the specifications from C++ code in series and generate the gold chain drawing. These drawing will be automatically converted in bitmap file and sent back to the user in order to let the user decide. Figure 4 shows the sample web page, which contained the primitive parts. And figure 5 shows the example of finished gold chain the user received.

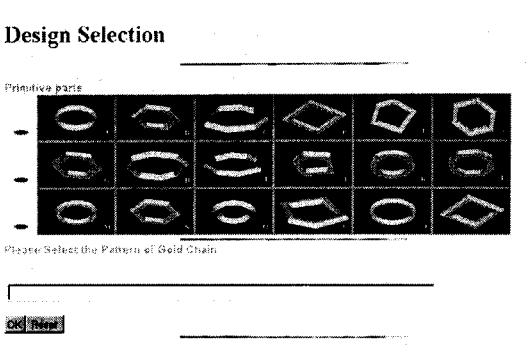

Figure 4 The Sample Web Page

6. Conclusions and Discussion

The development of the Real-time Intelligent Knowledge-based Computer-aided Design (RIK CAD) package initiates a new era of computer aid to engineering design manufacturing. This approach leads to the contribution of CE under the design circumstance of customized discrete product manufacturing in the design-oriented process. Currently, the prototype is being developed in the low cost windows environment with AutoCAD package due to the flexibility of AutoLISP buit-in capability. Moreover, the internet capability is increasing with JAVA and CORBA and thus, the package is now developing the JAVA Café and CORBA Cake to handle the faster, safer environment for the user company.

For future work, the development team is now implementing a significant progress in elaborating the CAD system that can facilitate the design process, evaluate the feasibility in manufacturing, and select the optimized design. The RIK CAD framework has been constructed as a major transmission wheel which keeps the developers focusing on the prescribed internal operating mechanism of the proposed CAD system. In addition it is proposed to extend the fuzzy expert system based on JESS on the RIK system to help deal with customer uncertainty with the activity-based cost model.

Currently, the project team has extended the CAD system development inside JAVA and real time database implementation for catalogue development.

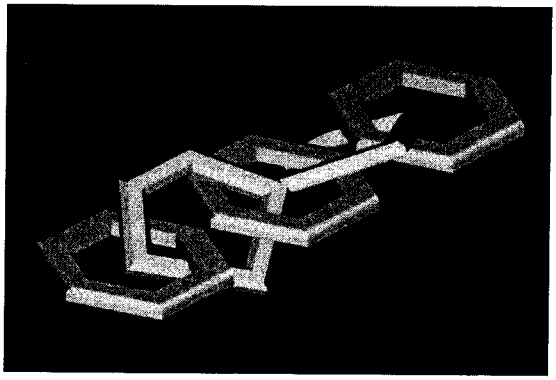

Figure 5 The Finished Gold Chain

Finally, it can be concluded that the future CAD system will evolve into a virtual manufacturing system using the internet facilities and transparency between the customers and the designer using the power of the computer communication in near future.

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