http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 11 (3): 368-371, 2012
ISSN 1812-5638 / DOI: 10.3923/itj.2012.368.371

Research on Rapid Design System for Semi-trailer Based on KBE

Zhou Xing, Sun Huan-Wu, Li Nan, Dou Wei and Yan Jie
College of Mechanical Engineering, Taiyuan University of Technology, Taiyuan 030024, China

Abstract: This study presents a Knowledge-Based Engineering (KBE) methodology for semi-trailer design. At present, many Chinese semi-trailer enterprises have low design level and their products often have a relatively short life-span. To solve this problem, it is necessary to integrate intelligent design process into semi-trailer design. Then a rapid design system for semi-trailer based on KBE is put forward. Combining with the UG development tools (KF, UDF, Part Family and Reuse Library), CBR (Case-Based Reasoning), parametric modeling and knowledge integration techniques, the rapid design system for semi-trailer is realized. The system provides appropriate suggestions and supports to promote working efficiency. Besides, it also achieves knowledge reuse and accumulation, improves the design quality and significantly reduces the design cycle.

Key words: Semi-trailer design, knowledge-based engineering, case-based reasoning

INTRODUCTION

At present, Chinese semi-trailer enterprises are mainly SMEs (Small to Medium-sized Enterprises). Their engineers often have low design level and do not understand the real reasons of the design, so they copy a lot (Guang-tao, 2009). Therefore, it is necessary to develop a smart application to help the SMEs. Many researches have been done to solve the problem. For example, some methods are studied to establish two-dimensional engineering graphics for semi-trailer rapidly (Sun-Jun, 1999). And many advanced design concepts have been proposed such as the modular design concept for semi-trailer design (Hong, 1999), application of KBE methodology (Lee *et al*., 1996) and so on. Though many researches have been done, there is still no application to rapidly establish semi-trailer three-dimensional model which can facilitate the optimizing of the structure and the storage of the design knowledge. Combining with the advanced design concepts, a rapid design system for semi-trailer based on KBE is just developed to solve the problem in this study. Present study aims to improve the design quality, reduce the design cycle enhance competition of semi-trailer enterprises.

CONSTRUCTION OF THE SYSTEM

The construction of semi-trailer rapid design system is divided into four layers. Data layer is at the bottom. This layer includes database of expert knowledge, standard component, design method and foundation data; The third layer is application support layer, mainly including CAD/CAE platform and database management system platform; The second layer is the application layer which fuses design knowledge with conceptual design and part rapid design system to accomplish knowledge driving; The presentation layer, which provides friendly man-machine interface for users to complete the entire design, locates at the top.

THE BASIC PRINCIPLES

Knowledge acquisition: Rapid design for semi-trailer is the design based on knowledge, different from the old design method only based on experience. The success of the design depends on the content of knowledge, so knowledge acquisition becomes the key to the design. The acquisition of design knowledge mainly includes the following five aspects:

- **Existing knowledge:** This refers to all accumulated knowledge in the past design, such as domain knowledge in design manuals, national standards, literatures, expert experience and so on
- **Market information:** This includes market demand information, out-sourcing parts supply information, design cost information and so on
- **Digital simulation:** This consists of optimization schemes on the structure, material and manufacturing provided by ANSYS and ADAMS
- **Prototype test:** It refers to information collected by semi-trailer prototype test
- **User responses:** These mainly contain received information recorded in the entire life cycle of its products

Corresponding Author: Sun Huan-Wu, College of Mechanical Engineering, Taiyuan University of Technology, Taiyuan 030024, China

In addition, CBR can learn by accumulation cases and simultaneously update its knowledge base automatically while learning.

Knowledge representation: Knowledge representation is mainly about how to state problems and how to store knowledge in a machine-interpretable representation. For the characteristic of semi-trailer domain knowledge, production rule and object-oriented technique are adopted as the knowledge representation methods. Then representation of case and design method will be mainly described.

A case is an instance defined over the scheme for a specific domain, mainly separated into two parts: Problem and solution. In order to facilitate computer to retrieve and match, cases are also divided into two parts: Graphics and feature data (Xiao-Li *et al*., 2010). They are separately stored in database in different form. Then the retrieval of cases turns into retrieving database, which provides more convenience.

Design method is the summary of the national standards, expert experience, etc. This knowledge mainly exists in the form of kinds of formulas, rules, loops, design tables and so on. And it has the following components-geometry, configuration engineering knowledge (Lovett *et al*., 2000).

- **Geometry:** Cylinder_1_Position = Block_1_Position+Vector (4, 3, 2)

Rules of this type can associate secondary parameter with key parameter. This feature, which is known as "parametric modeling", eliminates a large proportion of the repetitive tasks involved in producing a design.

- **Configuration:** IF Shaft number = 1 THEN Vehicle length ≤8600 mm AND Vehicle width ≤2500 mm and Vehicle height ≤4000 mm

This rule is described in GB 1589-2004. Rules of this type describe conditions that must be observed for configurations of components to be "legal".

- **Engineering knowledge:** IF Total_mass = 15t THEN Frame_height ≤300 mm

Rules of this type take expert experience into account at the design stage of product development.

Knowledge reasoning: Reasoning is a constant process of using knowledge. The reasoning methods include Rule-Based Reasoning (RBR) and case-based Reasoning (CBR). The method of RBR is mainly used to specific parameters based on expert knowledge CBR is mainly used to find a similar previous case for a new problem. Figure 1 illustrates the whole process of CBR.

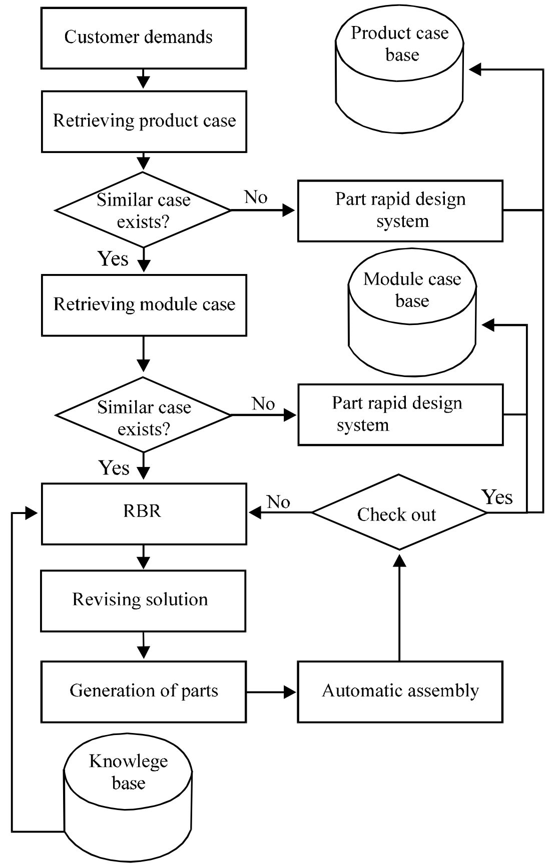

Fig. 1: The whole process of CBR

At first, the designers type the main parameters submitted by customers into the design system. After calculating the similarity degree between primitive designs and target cases, the system provides the most similar case to the designers. Second, the designers revise the newly generated solution for the current problem with the help of knowledge base. At last, the designers retain the final solution along with the problem as a case after being checked out. Otherwise, if there are no appropriate cases, semi-trailer can be designed through part rapid design system.

DESIGN EXAMPLE

The rapid design system has been developed using UGS NX 7.5, Microsoft Visual C++6.0 and Microsoft SQL Server 2008 under Windows XP. Meanwhile, many UG development tools (KF, UDF, Part Family and Reuse Library) have been used in this system. Part Family and Reuse Library are used to develop standard part library KF is the key of RBR (Unigraphics Solutions Inc., 2000).

Conceptual design system: The conceptual design system is used for reasoning the overall design of the semi-trailer. According to the characteristics of the semi-trailer cases, K^{th} Nearest-Neighbor Approach is adopted in the system (Vong *et al*., 2002). The process of conceptual design is as follows:

- At first, the system chooses the most important features of the design. In this system, $f^i = \{c_{j,}, (i = 1,3...n)$, where c_1 is the total mass, c_2 is types of semi-trailer, c_3 is shaft number, c_4 is axle-load, c_5 is the purpose

Second, the system calculates the similarity degree between primitive designs and target cases retrieves the most similar case to the users. In the retrieval stage of CBR, a simple similarity function is usually employed to find the nearest neighbor for the current problem from the reference cases:

$$SIM(c_K, c_I) = \frac{\left[\sum_{i=1}^{n} w_i \cdot sim(f_K^i, f_I^i)\right]}{\sum_{i=1}^{n} w_i}, (i = 1, 2, \cdots, n) \quad (1)$$

where, w_i is the importance of dimension i, sim is the similarity function for primitives, f_k^i and f_I^i are the values for feature f^i in the input and retrieved cases, respectively.

In case symbolic features are encountered:

$$sim(f_K^i, f_I^i) = \begin{cases} 1, f_K^i = f_I^i \\ 0, f_K^i \neq f_I^i \end{cases} \quad (2)$$

In case numeric features are encountered:

$$sim(f_K^j, f_I^j) = 1 - \left|\frac{f_K^j - f_I^j}{rang_j}\right| \quad (3)$$

where, $rang_j$ is the range of the j_{th} feature. If $f_k^i \neq f_I^i$, Eq. 4 is used to simplify calculation.

$$sim(f_K^j, f_I^j) = \frac{1}{1 + \left|f_K^j - f_I^j\right|} \quad (4)$$

At last, the most appropriate case will be put forward. Figure 2 illustrates the interface of conceptual design and Fig. 3 shows the result of the reasoning.

Part rapid design system: The modular design concept is adopted in part rapid design system, so the system is mainly divided into five parts shown in Fig. 4. Though each module design has different features, the basic principle is the same.

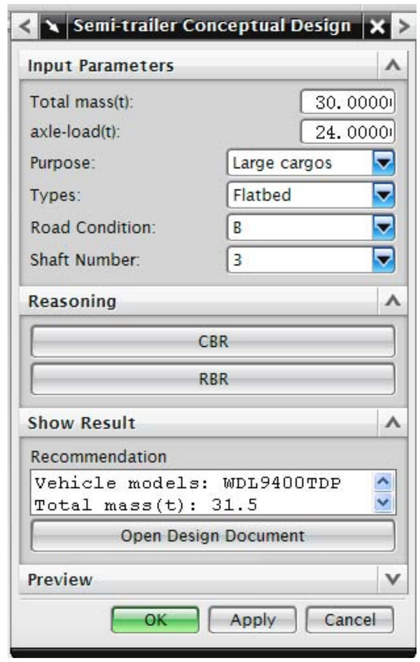

Fig. 2: The interface of conceptual design

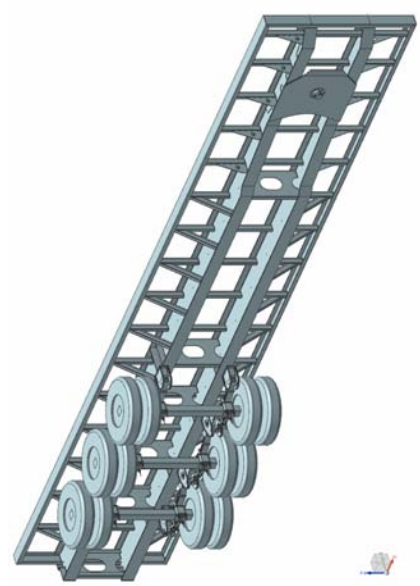

Fig. 3: The design case of semi-trailer

The first step of rapid design based on knowledge engineering is to establish parametric model in accordance with input design information. And some skills are used in parametric model.

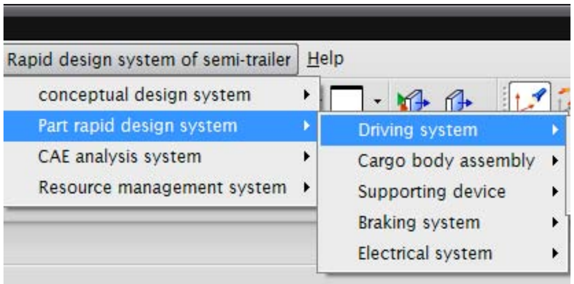

Fig. 4: Construction of rapid design system

- According to the characteristic of components, design intent, main control parameters and associating parameters need to be specified appropriately while components are established
- When sketch is established, datum plane and datum axis need to be set appropriately, which can make automatic assembly more conveniently. And all sketches require to be fully constrained
- When parameter associations are required between components, WAVE technique and Interpart-Expressions are used to achieve the goal
- Formulas and other knowledge such as materials are integrated into components in form of expressions and attributes

Then the rapid design of products is achieved through variety of knowledge reasoning methods.

CONCLUSION

This study describes the knowledge-based engineering technique applied in semi-trailer design. It is proved that the technique is useful. It not only saves time for the design of various structural elements, but also provides advices and explanations to the user whenever required. According to the characteristics of the semi-trailer design and the present situation of computer applications, a rapid design system for semi-trailer based on KBE is put forward. The system provides a way for the storage of semi-trailer design knowledge in a machine-interpretable representation to facilitate computers to address difficult problems. Simultaneously, its conceptual design system offers a method to select the most appropriate case from the case base while solving a new problem. And its part rapid design system provides the methods for detailed design of semi-trailer to improve the work efficiency. In the future design process, CAE analysis system will be developed. It will not only facilitate the users to optimize the structure, but also update the knowledge base using the optimization, which makes the design quality better.

Compared with traditional Chinese design, the system has also been verified to be very effective, especially for SMEs. It can reduce design cycle of semi-trailer, improve the design quality play a positive role in the accumulation of domain knowledge.

ACKNOWLEDGMENT

The work presented in this paper is supported by The National Natural Science Foundation of China (No.51075294) and Technology Star Project of Taiyuan Shanxi province (No.11014922).

REFERENCES

Guang-tao, Y., 2009. Key elements and matters of the design of semi-trailer. Commer. Veh., 6: 108-110.

Hong, Y., 1999. Modularity design of semi-trailers. Spec. Purpose Veh., 2: 7-9.

Lee, K., D. Lee and S.H. Han, 1996. Object-oriented approach to a knowledge- based structural design system. Exp. Syst. Appl., 10: 223-231.

Lovett, P.J., A. Ingram and C.N. Bancroft, 2000. Knowledge-based engineering for SMEs-a methodology. Mater. Process. Technol., 107: 384-389.

Sun-Jun, H., 1999. Design of galleries of semi-trailers. Spec. Purpose Veh., 4: 27-29.

Unigraphics Solutions Inc., 2000. UG knowledge fusion. pp: 15-94. http://vs.technologyevaluation.com/search/for/ug-knowledge-fusion.html.

Vong, C.M., T.P. Leung and P.K. Wong, 2002. Case-based reasoning and adaptation in hydraulic production machine design. Eng. Appl. Artif. Intell., 15: 567-585.

Xiao-Li, Z., H.U. Dong-Ming and W.U. Bao-Gui, 2010. Research on knowledge-based design of complex mechanical product. J. Dalian Univ. Technol., 50: 917-920.