DMU-Oriented Design Based on Cases and the Research on KBE System

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Abstract
By analyzing the technology composition of Digital Mock-Up (DMU) and Knowledge Based Engineering (KBE) system, the DMU-Oriented design methods based on cases is proposed, which is significant for the development of model design methodology. The design flow used in the KBE system is developed based on the product cases and neural network technology, and the KBE system for motorcycle design is described in detail.
Keywords Knowledge acquisition, DMU, KBE, Intelligent design

1 DMU&KBE

DMU (Digital Mock-Up) technology is the technology of product development and design growing with the development of computer, computer graphics knowledge and other emerging technologies[1-3]. There is no consistent definition so far. The main model of DMU is a dendriform relation model based on the hierarchical structure of products. It describes the assembly information, functional information, movement relation information and cooperative relation information of the whole product, and also expresses design parameter and engineering semantic constraint of products parts and describes the design information about each stage of the life circle of the whole product.

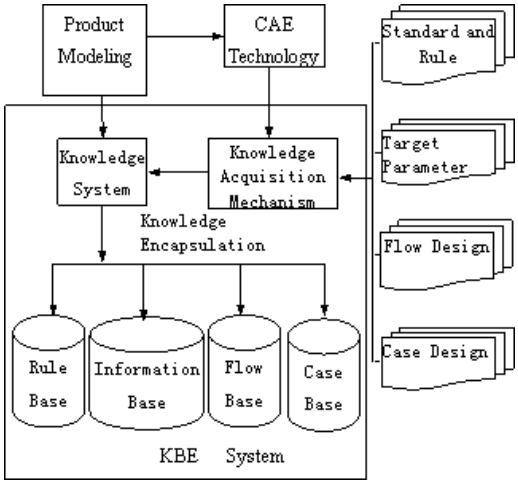

Fig.1 The Framework of KBE

KBE (Knowledge-Based Engineering) is a computer integrated disposal technology, which provides the best solutions to engineering problems and tasks through the driving and reproduction of knowledge[4]. The four cores of KBE technology are knowledge system, knowledge acquisition, product modeling and analysis technique. Knowledge system is mainly used to denote and process engineering design knowledge, facing to the engineering design personnel and embodying the intelligent level of system. Knowledge acquisition technique is primarily applied in engineering knowledge acquisition, including automatic acquisition and manual acquisition, embodying the knowledge of experts in all fields, making the whole design system improve engineering design and analysis ability step by step, thereby making the system achieve the goal of KBE system of engineering design. The framework of KBE is presented in Fig.1.

2 Case-based Design

Case-Based Design (CBD) method is a reasoning method based on case applying in the design filed. Its design idea originates from human thinking modes. Confronted with the new design requirements, the similar design conditions, which happened before, usually emerge into the designers mind firstly, and according to them, the designer identifies a new design scheme associated with the standardized design rules[5-6]. The contents of case consist of the description of design problems, the design rationales, the evaluation of design scheme and the final design scheme. At present, the application of artificial neural network in reusing case experience and knowledge of parts is the relative advanced technology. The design process of Case-Based and NN-Based (Neural Network-Based) KBE system is summarized in Fig.2. The whole process involves four key technologies: case knowledge reuse, case filtering, case supplement and modification and case base maintenance.

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NN(Neural Network) indicates the given conception or knowledge by interlinking a great deal of nerve cells and connecting weight distribution. In the engineering that uses artificial network to acquire case knowledge, these cases which are systematically filtered and have appropriate similarity and corresponding results should be provided by the special adaptive algorithm of NN to learn the samples and constant modifying connecting weight distribution to meet the demands in order to make NN acquire the same exporting cases as much as possible under the condition of the identical input. This is the ideal process for NN to learn automatically. On this occasion, the case experience and knowledge will be transformed into the joint strength of each nerve cell in NN. When the error between output case and filtration one comes to a certain precision, NN finishes

the process of learning, and stores the acquired NN into case base simultaneously and establishes the corresponding relation with the relevant case.

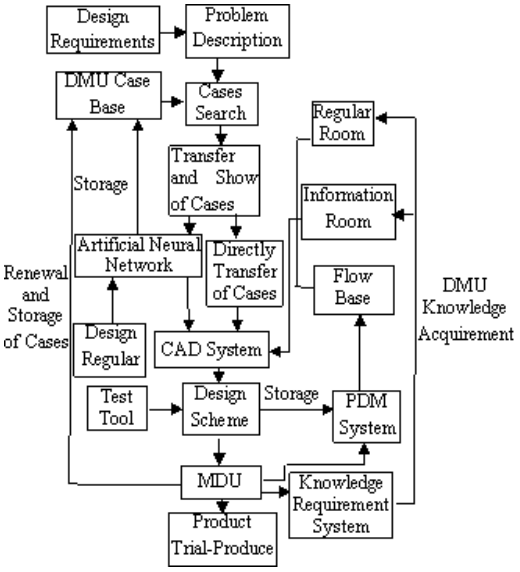

Fig.2 The design flow of Case-Based and NN-Based KBE

The structure-function model of motorcycle parts is the base of establishing artificial NN, and the artificial NN of cases can be set up according to the structure-function model of parts. We should analyze the cases structure after choosing the motorcycle parts cases. Firstly, the designer should analyze the relationship between the structure parameters of the parts and its function, and confirm what main structure parameter affects its function. Secondly, the designer presents the exact numerical range of every key parameter and function parameter, and the two parameters have different function relation in different count range, which shows the relationship between structure and function. We can adjust the function relation to make the output function and the case function similar as much as possible. For instance, the modal parameter of frame structure is the primary parameter that affects the comfort of four-wheel motorcycle. When designing the frame, the main structure parameters that have influence on modal parameter are the height and width between the front and the back upright pole of the frame, the length and width between the bottom and the top horizontal pipe of frame, the whole height of frame, the height of mid upright pole, the length of frame tail, the assembly angle and the materials of frame, displayed in Fig. 3. According to the design experience data that enterprise accumulates step by step, the Fitting Function relation of module parameter of multiple parameters can be

established to make the structure parameter based on cases acquire the function parameters that are close to the cases. This is the artificial NN for system to establish the motorcycle parts and the process of finish studying. Then we describe the design requirements, inputting the description into the learned NN, a integrated case experience scheme is output, and the final design scheme will be formed through modifying it according to the CAD system; or, we directly call the cases combined with CAD system to modify, at last, an outcome that meets the design requirements will be got. The application of NN and the directly call of cases is a side-by-side route, proceeding simultaneously. This is the design flow Case-Based and NN-Based KBE system.

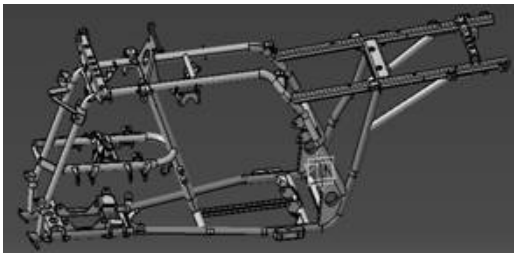

Fig.3 Frame of Four-Wheel Motorcycle

Searching cases includes the following procedures: distributing index, looking up the relative cases and choosing the best cases. The index of cases is to determine when we can use the cases in future and it indicates the parts deserved to learn in cases. When establishing the index, its relativity, the generality and the feasibility should be taken into account. The filtration of cases can be chosen with regard to the similarity of cases, and the calculation of the similarity of cases will be listed later.

2.1 The Calculation of Similarity of Property

When two properties are identical, the similarity is 1. The calculation formula of two properties is as follows:

$$Sim(T_i, S_i) = 1 - \frac{\triangle_d}{T_i} \tag{1}$$

In the formula, Sim is the similarity function; T_i is to show the certain property in design requirements of the object case; S_i is to show the corresponding property in the source case;$\triangle_d = |T_i - S_i|$.

2.2 The Definition of Attribute Weights

The setting of property can be designed according to the requirements of NN, and the user can configure the corresponding weights to the every property according to the different focus on design requirements.

2.3 The Calculation of the Whole Similarity of Product

$$Sim(T,S) = \sum_{i=1}^{n} W_i \times Sim(T_i, S_i) \tag{2}$$

$$\sum_{i=1}^{n} W_i = 1$$

In the formula, Sim is the whole similarity function, T is to show the object case; S is to show the case in the case base; n is to show the number of property of each case; W_i is to show the weight of the property of i.

The modification and supplement of case is the difficulty of CBD method, and it includes identifying the difference between case and problem, finding out the parts that require modification and reservation. According to the characteristics of case, the types of modifications are as follows:

(1) Direct change. When the cases fit the design requirements completely, it only requires altering the relative parameter of the previous case.

(2) Change with modification. Do partial correction and make use of the relative knowledge in this field.

(3) Scheme change based on frame. Store the new cases into case base after finishing designing new product

3 The Development of KBE System and Its Application Example in the Motorcycle Design

With the powerful secondary development function of UG, we can successfully develop KBE of knowledge-Oriented motorcycle based on UG, integrating it with PDM software (Team center), multi-CAE soft wares and database system to realize the intellectualization and being knowledgeable. The system consist mainly of four modules: the Assembly-Oriented design guide, the management of parts base, the analysis of man-machine engineering and the interface with PDM system.

3.1 The Assembly-Oriented Design Guide

The process of this KBE module is, first, entering the Assembly-Oriented design guide, configuring the basic performance parameter of the designed vehicle model. KBE program forces the designer to design and assemble parts from system-class parts. Because the system-class basic part of the whole motorcycle is frame, so the frame is the first part that is to be designed and assembled. Fig.5 shows the main interface of assembly design guide of frame of a four-wheeled ATV motorcycle. After the design parameters are completely defined in the design platformthe management system of parts base makes use of cases inquiry system to inquire

the storage position of the parts model in accordance with the requirements in the parts storeroom according to the design knowledge in the knowledge storeroom and these parameters, and it will be showed on the interface for the choice of designer according to similarity. After choosing the frame, the designers can establish the new frame according to the procedure based on cases and NN. After designing the new frame, we store it named by the number of file into the parts storeroom, and at the same time register the storage position of the file into the registration table of parts. The designer can enter the design of the rest parts fixed on the frame after finishing designing frame, and the process is similar to the design of frame.

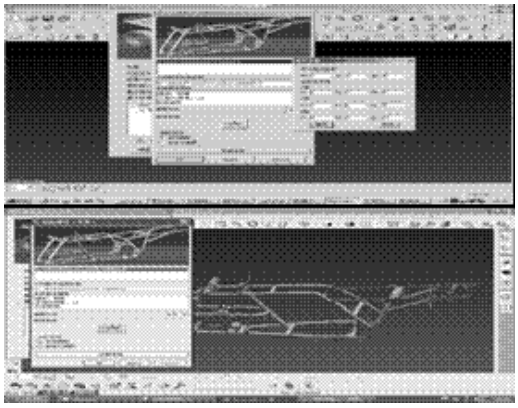

Fig.4 Interface for Frame Design of Oriented-Assembly

3.2 The Management of Parts Storeroom and the Analysis of Man-Machine Engineering

The cases base of KBE system is to establish the parts base and the management system of parts base under the condition of three-dimension CAD circumstance. These new established parts are stored into the right position of parts storeroom by the management system and registered its position information into registration table. The designers must simulate and analyze every function of the vehicle after accomplishing the assembly design of the vehicle. The following are KBE system and the integration interfaces of CAE analysis software: ADAMS, MSC. Patran, MSC. Nastran, ANASYS and so on.

3.3 The Interface to the PDM System

The main function of this module is to achieve the integration between KBE system and PDM system. The knowledge of design procedure of extracting DMU mainly include the scheme management procedure of DMU and the procedure of development assembly of the motorcycle DMU, storing the relative information with procedure into PDM system and achieving the reuse of the procedure

knowledge and experience.

4 Conclusion

This paper has discussed the composition of DMU and KBE technology, presented the products design procedure of KBE system based on cases and NN. Then, the KBE of motorcycle design based on UG that integrates with PDM and CAE is developed. The integration of DMU, PDM, CAE and KBE makes the analytical technology of product, the experiences of experts and the analysis results reused in the engineering design, improving the design efficiency and quality of products greatly, and it is an important direction of intelligent development of product design.

Acknowledgements
Project of nature sustentation fund for Chongqing science committee (CSTC, 2007BB0116).

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