THE REUSE STUDY OF SMALL AGRICULTURAL MACHINERY'S PRODUCT INFORMATION MODEL

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Abstract: It is estimated that more than 90% of industrial design activity is based on variant design. How to use the product information model of similar products and to improve design efficiency and the designer's creativity is a subject that is worth studying. This paper has set up the structure frame of small agricultural machinery product information model, and uses ontology to describe product information model. The described mechanism of product information model has been set up. The revise mechanism of product information model is researched. The results of study are used in the reused system of small agricultural product information model.

Key words: Product information model; ontology, Modification of product information, Small agricultural machinery

1. INTRODUCTION

The development of product is the intersection of market requests, customer requests and the knowledge, experience, creativeness, artistic quality of designer and all kinds of standards. How to unite the three items is a subject that is worth studying. In the methods of traditional product development, designers concentrate their energy on the unification of

This project is supported by the Natural Science Foundation of China No,50375146, National Basic Research Program of China No,2004CCA05800, The Doctoral Program Foundation of Ministry of Education of China No,20040337002, the department of international Science&Technology cooperation of China No,2005DFA70380, Zhejiang Provincial department of international Science & Technology cooperation of China No,2005C14005, and Zhejiang Provincial Natural Science Foundation of China No,Z503054)

Please use the following format when citing this chapter:
Sun, Xuejun, Jiang, Jiandong, Xu, Fang, Zhang, Libin, 2006, in International Federation for Information Processing (IFIP), Volume 207, Knowledge Enterprise: Intelligent Strategies In Product Design, Manufacturing, and Management, eds. K. Wang, Kovacs G., Wozny M., Fang M., (Boston: Springer), pp. 664-672.

requests and knowledge, experience, and making the product accord with all kinds of standards. This method limited the exertion of creativeness and artistic quality. Designers face on choose of being in a dilemma between efficiency and creativeness, artistic quality. It is estimated that more than 90% of industrial design activity is based on variant design.[1] So the reuse of product information model is an attractive product development method. The reuse of product information model can avoid the repetition of design effort. The reuse of product information can improve the exertion of designer's creativeness and artistic quality. The expressions, reasoning, choose, modification of design and appraisement of product information are the key technology during the reuse of product information. This paper sets up the reuse system structure of product information model, then expresses the product information model, and finally studies the design modification of product information.

2. THE SYSTEM STRUCTURE

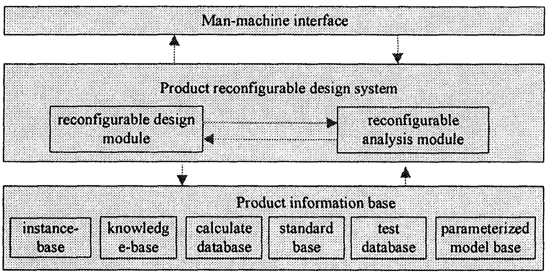

Figure 1. system structure chart of small agricultural machinery reconfigurable design system

Fig.1 is the system structure chart of small agricultural machinery reconfigurable design system. It mainly includes three parts: man-machine interface, production reconfigurable design system and production information base. Production reconfigurable design system is composed of by reconfigurable design module and reconfigurable analysis module. The reconfigurable design module receives the user requests from man-machine interface, then picks up the corresponding instance and parameterization model to have quickly and individuation design, which is according to some rules. The design results of reconfigurable design module are handed in reconfigurable analysis module to have some performance analysis, such as vibration analysis, work performance analysis and so on. The production information model-base includes instance-base, knowledge-base, calculate database, standard base, test database and parameterized model base. The instance-base mainly be used stored the instance that has successfully developed, during a new product development these instances can be reused or consulted. The product development experience of workers and the knowledge that is used during product development is stored in knowledge-base. When a new product is developed, designer and performance analysis engineer can study and use this knowledge to solve new problems. Calculate base mainly stores these data that need be calculated and will be used in the follow-up product development, for example the data of natural calculate frequency etc.. The national standard and trade standard of product development, performance analysis and the product performance will be stored in standard base. Test database mainly store some test results such as the data of production performance test and vibration test data etc.. Parameterized model base is used store the parameterized model of product parts and components. These bases compose of the production information base, and how to organize these data and make them become an organic whole, can be convenient used is the content of next part.

3. PRODUCTION INFORMATION MODEL

Fig.1 shows that the data structure of product information model includes parameterized geometry model, all kinds of calculated data and curve, mature theory knowledge, the practical experience of product developer, all kinds of test data and curve and all kinds of statutory standard. How to logically express and organize these data, and provide to reconfigurable design module and reconfigurable analysis module using is the key of modeling the product information model. Here we use the "ontology "to express and organize the product information model.

"Ontology" is a philosophy term, and is a description about the concept and relation of external being.[2,3] This paper uses ontology to express product information model with "task, problem solve method and domain" three aspects and " meta-ontology, ontology, and application ontology" three levels and "intranet connector, intranet connector" two tools.

Task (T) is the problem that this system will solve. Problem solve method (PSM) is the method that uses to solve problem, a problem can have one or many methods to solve, and every sub-problem also have one or many methods to resolve. Domain (D) is the knowledge when resolve problem, it can be separate into the domain knowledge of every sub-problem. Intranet connector (intra-C) mainly expresses the interrelation of the same aspect of one problem, for example: the interrelation between T1 and T2, the interrelation between PSM1 and PSM2 and so on. Internet connector (inter-C) is used to express the interrelation of different aspects of one problem, for example: the interrelation between T and PSM, the interrelation between T and D and so on. T, PSM, D, intra-C and inter-C are expressed with meta-ontology, ontology and application ontology.

Definition1 Meta-ontology meta-ontology is the cell ontology that can not be decomposed, and it is expressed by MOi.

$$DefMO_i = (Atr_i - name,\ MOb - name,\ Atr_{ij}, Val) \quad i = (1,2,\cdots,n);\ j = (1,2,\cdots,m)$$

Where: Atri-name—the description of attribute, is corresponding with one attribute of meta-ontology;

MOb-name—the name of meta-ontology;

Atrij—the explanation of the jth attribute;

Val—the value of Atrij.

Definition2 Ontology ontology can divide into meta-ontology, and it is the aggregation of multi-meta-ontology. One ontology should integrally describe the smallest subclass or the smallest connector of one aspect of problem. It is described with O. Ontology is the aggregation of meta-ontology, but it is not the simple element combination, and it is the composing with some constraint condition, it can be described as following:

$$O = (O - name,\ \Sigma DefMO_i,\ \text{int}ra - C_{ij},\ Atr_{ij},\ Val)$$

Where: O-name denotes the name of ontology;

$$\Sigma DefMO_i = \sum (DefMO_1, DefMO_2, \cdots DefMO_n),$$

the aggregation of metaontology attributes;

intra-Cij—the intranet connector of between meta-ontology;

Atrij—the explanation of the jth concrete attribute, it is the attribute that ontology has after the aggregation of meta-ontology;

Val—the value of Atrij.

Difination3 Application ontology application ontology is the smallest resolve cell of one problem; it is expressed with Apl-O. Application ontology is a aggregation of ontology and meta-ontology that aims at one concrete problem. It is expressed as following:

$$Apl - O = (Apl - O - name,\ \sum DefMO_i,\ \text{int}ra - C_{ij},\ \sum DefO_i,\ \text{int}er - C_{ij},\ Atr_{ij},\ Val_i)$$

Where: Apl-O—name—the name of application ontology;

$\Sigma DefMO_i = \sum(DefMO_1, DefMO_2, \cdots DefMO_n)$, — the attribute aggregation of ontology who compose the application ontology;

intra-Cij—the intranet connector between meta-ontology;

$\Sigma DefO_i = \sum(DefO_1, DefO_2, \cdots DefO_n)$,—the attribute aggregation of meta-ontology who compose the application ontology;

inter-Cij — the internet connector between meta-ontology, between ontology and between meta-ontology and ontology;

Atrij—the explanation of the jth concrete attribute of solved results.

Val—the value of Atrij.

From the description we can know that ontology is an extensible knowledge expression method, and it includes and describes the data, data structure, data type and document structure with the structure of tree. Besides that, ontology can include semantic to describe the knowledge that has good structure. In knowledge database, first order predicate logic, production rule, frame, table and so on all these expression methods have good structure at format, and can be directly described by ontology. Ontology also can include hyperlink in document, and can make one node with many nodes, and realize the relation of one to many and many to many, and can directly describe the relation of all kinds of graph structure. Ontology provides a uniform format to describe first order predicate logic, production rule, frame, table, process, semantic network and graph etc. many kinds of type knowledge expression methods, can inosculate different kinds of knowledge in a whole knowledge database. Ontology takes the extensible tree structure to describe knowledge, which can expediently extend, modify and delete knowledge of knowledge database, and can expediently manage and maintenance knowledge database. These merits of ontology can realize the description, expression, management and maintenance etc. function of engineering database.

4. THE MODIFICATION OF PRODUCT INFORMATION

The reuse will be concerned on the search of data and knowledge and the modification of product information model and components [4]. Here we will study the modification of task model and components. The process of redesign will be expatiated, and how to modify the product information model to satisfy the new design request will be studied. Fig.2 is the control flow chart of product information. The reused model divided into three parts: design request, the description of design object and the harmonization of design process. The four components that related to design request are the following. The first component is modification, this component mainly analyses current design requests, comes into being the modification advices. These advices will be compared with each other. The second component is guided mend, which according to the design theory of knowledge base modify the design request with guided mend. The third component is the updating of current description, this component stores and modify the current design requests. The fourth component is the updating of modification history, this component stores and modifies the modification history of design requests. The four components that related to design object description also includes modification, guided mend, updating of current description and updating of modification history.

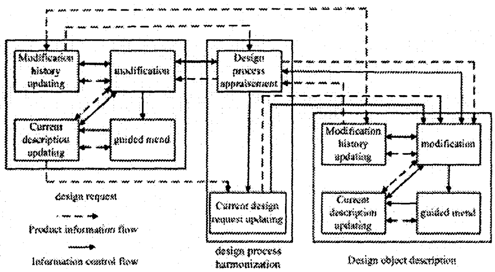

Figure 2. product information modification control flow chart

The two components that related to the harmonization of design process are the following. The first is the appraisement of design process. The status of design process will be appraised and controlled. This component mainly appraises the description of design object whether or not softies the design requests. The second is the updating of current design requests. This component stores and modifies the current design requests

While redesign the product based on the product information model, the sub-components of design requests and design object description that is redesigned will be modified. Every sub-component has the following operations. The first is the analysis of current description. This phase will study and analyze the problem that need solve in current design request constrain set and design object description. The second is the confirmation of modification center focus. This phase will confirm the part that must be modified in current design requests and design object description, so that to resolve the problems. The third is the conformation of modification method. This phase will confirm the modification method that be used to modify the part. The modification method is obtained from knowledge base or is provided by designer or expert. The fourth is modifying component according to the modification method.

The component and sub-component will be described by ontology. Following is an example of product information modification.

The initial design requests are: RQS_0 = { RQa, RQb, RQc, RQd}

Where: RQS—the product design request set;

RQ—the product design request.

The initial design object description is: DOD_0 = { PF, HD, HE, ID }

Where: DOD—the description of design object;

PF—the formatting disposal of product information;

HD—the confirmation of precondition;

HE—the appraisement of precondition;

ID—the description of product information.

The design process will be appraised by the harmonization component of design process. The result of appraisement shows that DOD_0 can satisfy RQS_0. The system restarts the design request and the design will continue. Knowledge engineer (KE) brings forward two new design requests RQ1 and RQ2. New design request is analyzed. New design request RQ1 makes the function more perfect, and it must be satisfied. RQ2 is a secondary design request. The design object description is analyzed and to check if it satisfies the design request. The result shows that the design request of RQ1 is not satisfied. In order to solve this problem, the design object description is modified.

The updating of modification history:

RQS_0 = { RQa, RQb, RQc, RQd}

RQS_1 = { RQa, RQb, RQc, RQd, RQ1, RQ2}

Rationale ($<RQS_0, DOD_0>$, $< RQS_1, DOD_0>$, method(KE)) .

The modification of DOD:

1) the analysis of current description, current DOD can not satisfy the all the current design requests.
2) The confirmation of modification center focus, setting the modification focus as {HD}.
3) The conformation of modification method, the select of modification method is operated based on knowledge base.
4) Modification, HD is replaced by component – libstructD that can have a disposal of structurization for precondition. This component can produce general sub-component – libG, contrastive sub-component – libC and select sub-component – libS. These operations will be renamed.

The updating of current description of DOD:

The current description is updated as: {PF, HE, IO, HD*, HD*:HG, HD*:HC, HD*:HS}

The updating of modification history:

The modification history is updated as: DOD_0 = { PF, HD, HE, ID }

$DOD_1 = \{PF, HE, ID, HD^*, HD^*{:}HG, HD^*{:}HC, HD^*{:}HS\}$

Rationale($<RQS_1, DOD_0>$, $<RQS_1, DOD_1>$, replaced_by (HD, HD*))

Rationale($<RQS_1, DOD_0>$, $<RQS_1, DOD_1>$, meant_to_satisfy(HD*, {R1}))

Rationale($<RQS_4, DOD_0>$, $<RQS_4, DOD_1>$, method(library_consutation))

Rationale($<RQS_4, DOD_0>$, $<RQS_4, DOD_1>$, is_based_on(HD* , libstrucD))

Rationale($<RQS_4, DOD_0>$, $<RQS_4, DOD_1>$, is_based_on(HD*:HG , libstrucD:libG))

Rationale($<RQS_4, DOD_0>$, $<RQS_4, DOD_1>$, is_based_on(HD*:HC , libstrucD:libC))

Rationale($<RQS_4, DOD_0>$, $<RQS_4, DOD_1>$, is_based_on(HD*:HS , libstrucD:libS))

The appraisement of design process:

The product object description satisfies the RQ1, and does not satisfy the RQ2. DOD will be continued operation to satisfy RQ2.

5. APPLICATION INSTANCE

The product information of small agricultural machinery is described by ontology. During the design the product information model of small agricultural machinery is reused and modified by the method of section3. Fig.3 is the frame of small agricultural machinery reused module. Through this system designer can expediently reuse the product information model of small agricultural machinery, and it also can make the designer concentrate their energy on the creativeness and artistic quality of product.

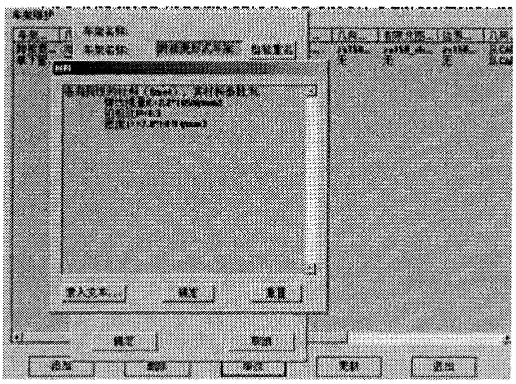

Figure 3. The reuse model of frame

6. CONCLUSION

This paper sets up the system structure of small agricultural machinery product information reused design. The description of product information model and the reused mechanism is emphases researched. The product information model is set up by ontology. The idea of component is used to set up the product information model mechanism. This paper brings forward the method of product information model selecting, modification and reuse. The results of research are primitively used in the small agricultural machinery configurable design system.

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