

AN XML-BASED DIGITAL MOCK-UP SYSTEM FOR HETEROGENEOUS ASSEMBLY

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ABSTRACT

Digital Mock-Up(DMU) system, a tool to build a virtual mock-up in the design stage, has been used to prevent interferences and mismatches during precision design processes. Using the virtual assembly tool, engineers are able to design precision and interference free parts without making physical mock-ups. Instead of a single CAD source, several CAD systems are used to design a complex product in the distributed design environment. In this paper, a heterogeneous multi-CAD assembly method is proposed through an XML and the lightweight CAD file. XML data contains hierarchy of the heterogeneous multi-CAD assembly. The lightweight CAD file produced from various CAD files through ACIS kernel and InterOp includes not only mesh and B-Rep data, but also topological data. It is used to visualize CAD data and to verify dimensions. The developed system is executed on desktop computers. It does not require commercial CAD systems to visualize 3D assembly data. Assembly of heterogeneous models is conducted to verify the effectiveness of the developed DMU system on the Internet.

KEYWORDS

Assembly, Digital Mockup, Heterogeneous CAD, lightweight CAD file, XML

INTRODUCTION

Design of cars and aircrafts requires a lot of engineering collaborators. Most of design modifications, related to manufacturability and assembly, are required due to mismatches and interferences between neighboring parts. To reduce such mismatches and interferences, a real mock-up has been used. CAD systems are applied to verify and check the assembly process. DMU systems have been used to prevent the interferences and miss matches during precision design processes. Using DMU

systems, designers are able to design precision and interference free parts without making physical mock-ups.

Rezayat[1] has applied XML to exchange CAD information. In order to exchange CAD data, Rezayat translated topological CAD information into XML data by using KBPD(Knowledge-Based Product Development). In addition, he proposed a DTD type schema called CADML(CAD Markup Language). Chen et al.[2] studied a real-time web-based collaborative design for assembly, which is called e-Assembly. By using ACIS kernel and the model of CAR (collaborative assembly representation), they devised a real-time collaborative tool applicable to verifying assemblies. Jezernik and Hren[3] developed a low cost VR(virtual reality) system by using XML and VRML. JT of UGS[4] and HSF of HOOPS[5] visualize assembled parts composed of heterogeneous CAD data. However, they do not generate visual data efficiently in various PDM systems because they are not interfaced with XML or STEP/PDM schema.

In this paper, visualization of an XML based DMU system for assembled parts composed of heterogeneous Multi-CAD data is proposed through the visualization of the lightweight CAD file [6]. The developed system does not require expensive commercial CAD systems. Cost of ownership is cheaper than other systems. In addition, the system has a function of real-time interference check, dimensional check, and design verification of heterogeneous multi-CAD assembled parts on the Internet environment. Lightweight CAD data [6] are used for sharing model information. XML is used for displaying and interfacing BOM (bill of material) of assembled parts. By designing a schema based on an international standard of ISO/STEP PDM,

the developed system are able to interface with most commercial PDM systems. In order to interface with other systems, modified positional information generated in the assembly process is stored as an XML format and is registered in the PDM system database.

VISUALIZATION OF ASSEMBLY

In this paper, visualization of assembly is designed by PDM schema of STEP standard. Fig. 1 shows an XML schema structure of the assembly and parts. In Fig. 1, the XML schema structure consists of subordinate assembly, sub-assembly, and its part, component. The sub-assembly is able to adopt another assembly or parts.

The parts and assemblies have matrix data to represent position information. The matrix data containing position information are formed with transformation matrix (V1~V9) and position vector (T1~T3) of parts or sub-assemblies at 'Position'. 'Name' on Fig. 1 means a name of the part or sub-assembly on BOM. 'Id' is a number to distinguish assemblies or parts. 'Type' means a kind of the link data. According to the 'Type', users select appropriate translator for visualization. 'Version' describes the version of drawings. 'Higher_info' is an entity representing higher level information, and it supports a searching function of a hierarchy in the multi-level assembly. 'Link' in a assembly supports the connection between sub-assemblies or parts. 'Link' in a part links physical visualization data. In this paper, XML schema expresses up to N level assemblies and accesses CAD BOM. As the XML data is designed according to DMU of the multi-level assembly, higher and/or lower stage searches are conducted conveniently. Therefore, various CAD data registered in various PDM systems are easily interfaced to the developed XML schema.

SYSTEM ARCHITECTURE

Fig. 2 shows overall structure of the proposed system. The system consists of following modules: CAD API (application programming interface), PDM server and data base, Web server and servlet engine for web interface, data translator for visualization, and PDM-viewer client.

Operating procedure of the system is conducted as follows: Various CAD data are registered in PDM by selecting the 'Check in' menu of the

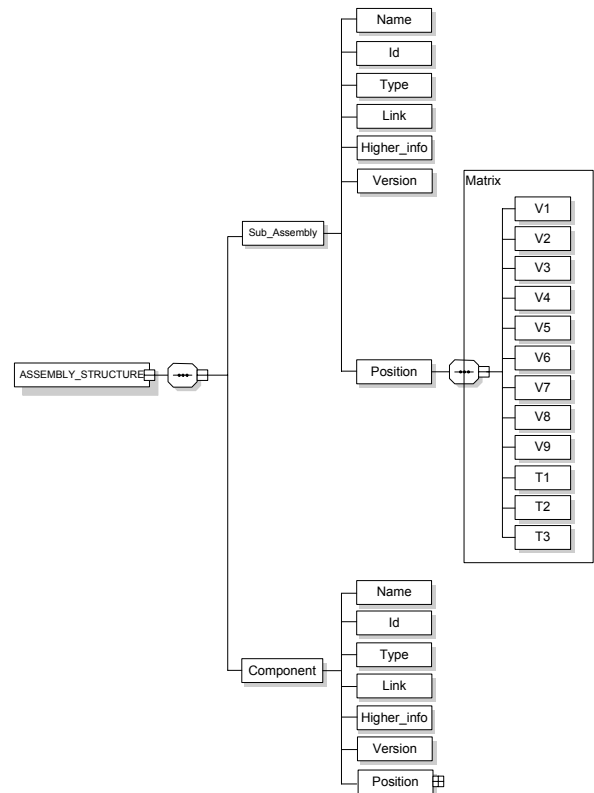


FIGURE 1. XML schema structure for assembly.

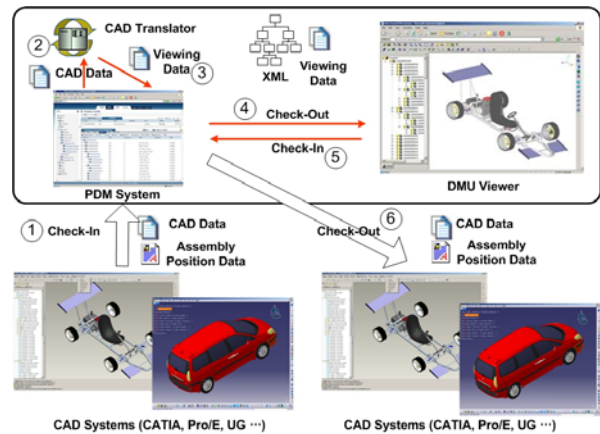


FIGURE 2. Overall framework of the DMU system.

PDM system. The PDM menus are constructed by CAD API. When the CAD data are registered into the PDM, the system extracts position and assembly information of the CAD data by using the CAD API as shown in Fig. 2 ①, and register them to the PDM data base.

The CAD data, registered in the PDM system, are translated to visual data by the CAD Translator as shown in Fig. 2 ②, and managed

by the PDM system as shown in Fig. 2 ③. When users check out an assembly needed to be verified, then the DMU web viewer is plugging into the web browser. The assembly XML and the lightweight CAD file as visual data of components are visualized on the web viewer as shown in Fig. 2 ④. After verification by the assembly DMU, the system checks in the assembly on the viewer, and then delivers the changed assembly position by XML and shows it. The verified file, checked by DMU web viewer, is able to be verified again on CAD systems. To be verified on the CAD system, the file should be searched through the PDM system, and then 'Check-out' to the CAD system. According to these procedures, users are able to check whether the CAD data have interferences. If there are interferences, clients are able to modify those interferences, and register modified data through check-in procedure of the PDM system.

GENERATION OF VISUAL DATA

Most PDM systems convert CAD data to visual data for efficiency and security. In this paper, visual data are generated separately as the component file and the assembly information. CAD data corresponding to parts generate visual data after conversion, but the other CAD data corresponding to assembly store both connecting and position information as matrices including visual data. These assembly data corresponding to sub-parts of the PDM system data is obtained without conversion. Using the information, clients are able to search the data on the PDM. An XML-writer generates an XML files to be used for visualization. The XML-writer was developed by using Xerces XML Parser.

In general, the generation process of visual data converts all CAD data of an assembly at once in the translation server. To do like this, a high performance translation server is required. However, using the proposed method of this paper, only the conversion of parts of the visual data is required. Minimum requirement of the translation server is limited to the size of the maximum part. If an assembly is composed of duplicated parts, the visual data might be reduced remarkably. If there is frequent design modification, the translation server should have big capacity for data storage. However, as only the visual data of the modified parts are required in this paper, clients save memories and reduce the server size.

CASE STUDY

Application of the XML schema

To implement the developed assembly verification system using XML, previously developed lightweight CAD translator [6] and the XML file composer developed in this paper are used. Oracle is used as a database of the PDM system. Fig. 3 shows an example of an XML file and the lightweight CAD data generated when the visualization data is required at the PDM system. [A] of Fig. 3 saves relative position data of each part to 'Position'. [B] of Fig. 3 saves link information of the real visualization data to 'FilePath'. The visualization data link of [B] is connected to [C] of Fig. 3 to visualize data. When these parts are connected to the CAD system, they are replaced with CAD data. Eventually, it allows the DMU verification is conducted on the CAD system.

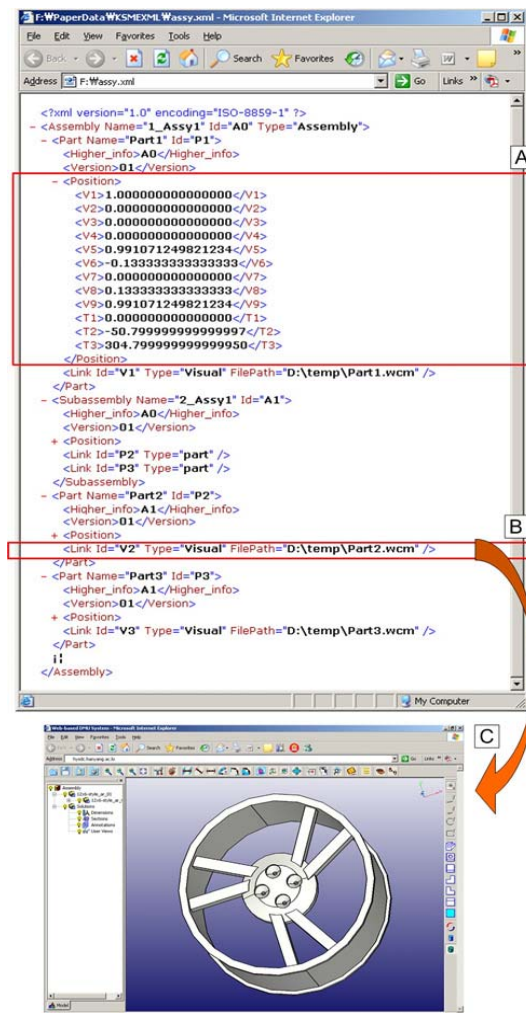


FIGURE 3. CAD assembly using an XML file.

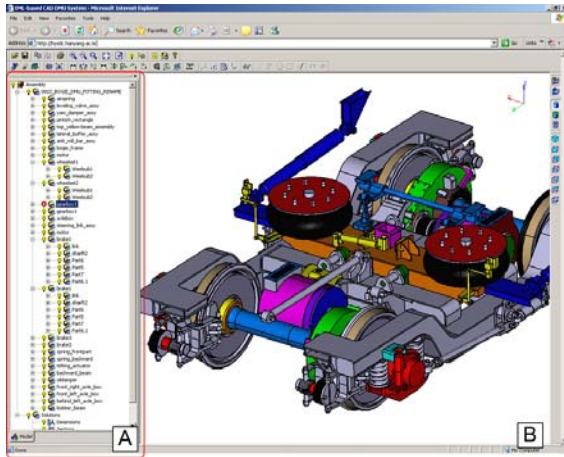


FIGURE 4. Bogie assembly for multi-level DMU.

Application of Multi-level Assembly

A bogie assembly shown in Fig. 4 [B] is used as a case study. It is a 3-level assembly. CAD data designed by a CAD system are registered in the PDM system through the 'Check in' function. Using this function, all part files and conversion matrices at each level of the assembly are registered on the PDM system at once. The registered assembly file is verified step by step through the various searching functions of the PDM system. The assembly at each level is able to be visualized and DMUed by the viewer developed in this paper. In addition, this system represents BOM structure of an assembly as shown in Fig. 4 [A]. It confirms the case study is a 3-level assembly as shown in Fig. 4 [A]. It is concluded that the developed system are able to be applicable to visualization and DMU of any levels of assembly.

CONCLUSIONS

By designing an XML based Digital Mock-up system for heterogeneous multi-CAD assembly, following conclusions are obtained:

- (1) Using XML technique, the data structure of the heterogeneous multi-CAD assembly is constructed. The XML-based DMU system has been devised and verified.
- (2) As the XML-based assembly system is designed according to the international standard, STEP PDM schema, the developed system is interfaced with various PDM systems.
- (3) As the feature information is constructed through the lightweight CAD data and the assembly data are designed by XML, multi-level assembly and visualization of the feature data are performed efficiently.

(4) Visualization data of an assembly are divided into parts and sub-assemblies. As the parts include feature data and the sub-assemblies include only the position data of each part, all visualization data are generated and managed very efficiently.

(5) As the system is applicable to visualization of the assembly data through the generation of modification of parts, advantage of the developed system is maximized when it is used to design an assembly requiring frequent design modification.

(6) Effectiveness of the multi-level assembly of heterogeneous CAD files linked with the PDM and DMU viewer systems is confirmed through the case study.

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