Application of XML to the graphic exchange technology of the modular fixture

GUOLIN DUAN, JIN CAI, XIAOQIAN CHEN, TAO YAO, ANPING XU
School of Mechanical Engineering
Hebei University of Technology
Hongqiao District, Tianjin City, 300130
P.R. CHINA

Abstract: Using computer-aided modular fixture (CAMF) system to fixture configuration and assembly could save time and be efficient. The MF element library (MFEL) was generally connected with a certain special CAD system, so data exchange should be carried out if different CAD platforms shared it. The MF graphics were divided into many elements, then CSG-based method was used to draw the MF graphics, based on that, MF data was described by XML architecture. Thus, the data mapping between the MF graphic information and XML architecture could be constructed. Last, the XML-based MF graphic system can be applied to various CAD platforms, providing technological and theoretical references for MF industries or different MF enterprises to communicate graphic library data.

Key-Words: modular fixture, elements, CSG, XML, data mapping

1 Introduction

Economic entities including countries, regions, enterprises and persons all need to react to external changes, that is, to communicate with each other. Information sharing is based on communication. The most important exchange should be CAD data inside or outside of enterprises [1].

CAD plays an important role in product manufacturing process. With the appearance of CIMS and product lifecycle, CAD in enterprises is no longer working on computers alone but more and more related with CAX systems such as CAPP\CAM\CAE and PDM\ERP data source management.

In the areas of engineering and manufacturing, 3D entity models are used nearly in the whole product lifecycle. Generally not one kind of CAD system is used in enterprises, dissimilar CAD systems need to be alternated at different product design stages (for example, AutoCAD, SolidEdge, Pro/E etc.) [2]. Data must be exchanged exactly between various CAD systems. But, it is nearly impossible to share data files between applications because of geometry and topology of the models. So, data communication has become an urgent problem. Conversion must be carried out when different CAD systems share the same data [3, 4, 5]. Internal enterprises usually transmit data in heterogeneous platforms by taking advantage of standardized neutral interface files (IGES, STEP, DXF etc.). However, the neutral interface files are not full and data definition has difference in CAD platforms, ambiguity will appear when CAD system explains those files. After data are transmitted, many problems appear such as information is lost and not consistent. Further more, with the development and application of CAX technology, the need of home enterprises for transmitting data efficiently between CAD platforms or applications is more and more strong. Now, industry production is inclined to resource sharing, data communication and real-time cooperation based on net. Roy and Kodkani [6] developed an open collaborative design environment in the CAD setting of a networked enterprise and proposed using a translator to exchange CAD models into VRML-based models which then can be viewed over the WWW. C H Chu, C Y Cheng et al. [7] illustrated the Web-based collaborative visualization (WVC) in which a prototype system was set up, providing a visualized 3D product design and communication with the design engineer. This paper also widened the view of data sharing and communication.

2 Related works

After W3C (World Wide Web Consortium) published its XML1.0, technologies and ideas expressed by XML expand the field of view to solve data exchange problems. Because the standalone computer-aided fixture design systems (FDSs) have mainly been deployed on specific computer systems or on specific CAD systems, more and more researchers are interested in this field. XML can express many kinds of data such as words, graphics and sounds because of its flexibility, standardization and opening, which makes it easy for XML to exchange data. So, XML is supported by many companies. To apply XML to CAD data exchange may help to solve the problem of net-based data communication trans-platforms [8, 9]. Using XML to describe CAD data can transmit and convert files smoothly among different computers [10, 11, 12]. F Mervyn et al. [13] have developed a complete Internet-based interactive fixture design system (IFDS) which is versatile and interoperable on different operation platforms. They developed 3 tier thin client-fat server architecture and the fixture design XML file aids in creating an Internet-centric FDSs and decoupling FDSs from traditional CAD systems. Wagner et al. [14] have implemented a IFDS over the WWW named as FixtureNet. But there are relatively fewer papers that come to how XML is used in element library, which is just this paper concerns.

Fixture element library (FEL) is usually integrated with certain CAD platform and can not be used trans-platforms and on WEB. But FEL is important to improve fixture design efficiency and qualities. Integration between Fixture element and platform restrain the use of FEL in other platforms. The traditional way to solve this problem is to provide element library with neutral interface on the basis of DXF, IGES and STEP, but the way do not use B/S-based Web application and the neutral files behave differently in heterogeneous CAD platforms [15, 16]. That XML is used on Internet provides an effective way to describe CAD information and Internet-based trans-platforms information communication. Using XML in element library helps to resolve net-based data communication trans-platforms. Standardized elements are described with XML neutral documents can transform a standardized element library (SEL) to other CAD systems. Thus, much work can be reduced when multi-CAD platform construct SELs and the adaptability of SEL to heterogeneous CAD platforms can be advanced by general resource sharing [17]. MFEL has two outstanding merits, namely, Platforms independency and network friendliness.

3 Mapping between MF graphics information and XML documents

3.1 The data structure of graphics

Graphics are classified according to their shape. In CSG, each graphic is regarded as a combined body formed by basic 3D solids obtained by Boolean operations. In this system, basic geometric bodies (BGBs) are also called elements including cylinders, cubes, cuboids, globe, stretch body and revolving body, the data structure consists of three parts: position, geometry and additional information. The base point, orientation of revolving and angle of the geometric body are described in position information. The geometry information is made up of original base, geometric dimensions, outline and Boolean value. The information of simplified line (SL) (type and position) is expressed by additional information. The data structure must be mapped to XML architecture when it is transformed to XML. XML data relevant to BGBs is a tree structure including a root element and its sub-elements. Root element and its sub-elements all have names, property, contents and each element can include other elements. Table.1 is the mapping between graphic data and XML data. Fig. 1 shows the data structure.

Table 1 Mapping between graphics data and XML data

Mapping table				
XML data	**Root element**	**Positional element**	**Geometric element**	**Additional element**
Element name	Types of elements	New base, revolve a	Geometric characte line, face and a	Additional information
Element contents	Boolean value	Revolve angle	Dimensions	Bore diameter
Element properties	Position and ident of base point on	New base coordinate	Geometry character	Types of SLs and face they b
Element numbers	one	Four at most	Many	Number of SLs
Including other elements?	Positional, geomet additional sub-ele	No	Possible	Yes

3.2 Modeling and data mapping

The process of abstracting information into data is called modeling. Now, there are generally two kinds of models, namely, concept model and data model. Data model including at least data structure, data operation and constraints in order to describe the entity types and their relationship. The two kinds of models are called mathematic model (MM). Firstly, the objects in reality are abstracted to concept model when modeling is conducted, and then concept models are transformed to data model supported by computer. Data transformation must be adopted when graphic information (GI) is expressed as XML data (XD) owing to their differences in mathematic model or data structure. Data transformation usually includes data structure transformation (this circumstance aims at GI and XD coming from the same MM), transformation of MMs (it is used when GI and XD are from different models) and reconstructing MMs (it happens when GI is in the form of object entity or MM transformation can't be realized).In CAD domain, CAD data format is not corresponding to XML architecture. So, XML-based data transformation is better fit for transformation of MMs and reconstructing MMs[18].

Data mapping technology is adopted so as to make it possible for XML documents to express heterogeneous graphic data and transform data from XML to graphics, or, contrariwise.

A valid and logical data mapping should satisfy following terms [19]:

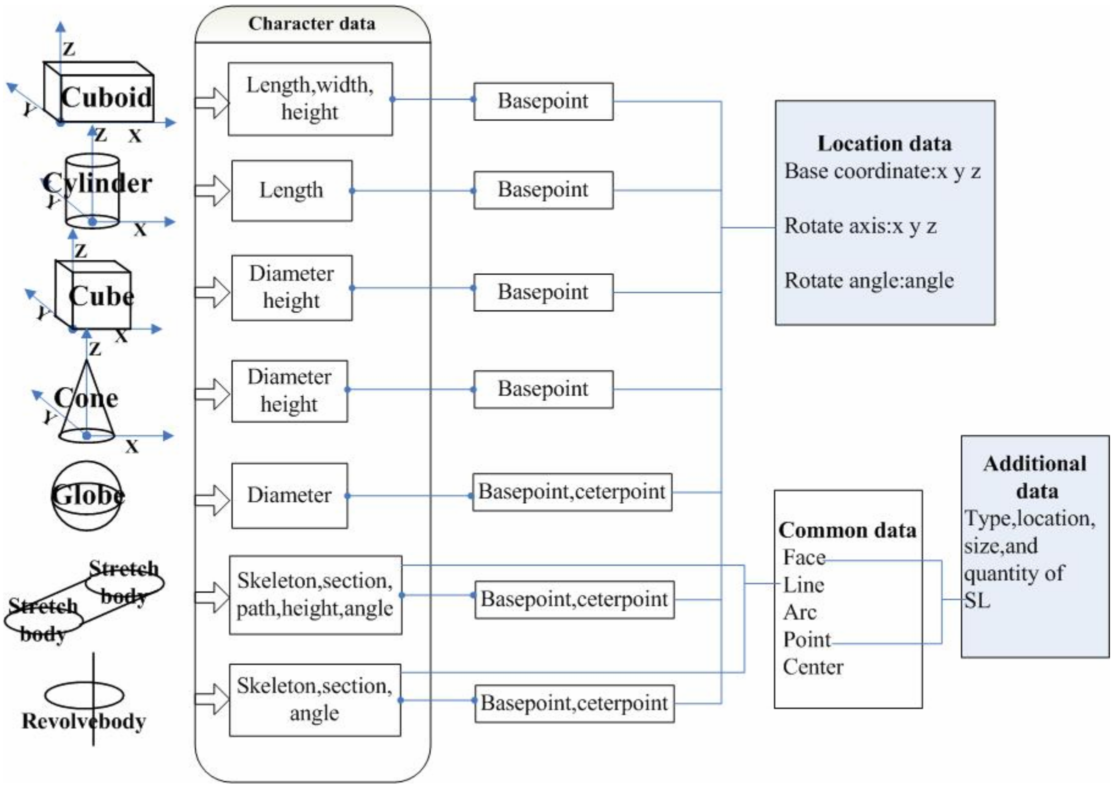

Fig.1 Data structure

(1) Integration of data, that is, data description to geometric definition of the graph should be integrated without losing any graphic information.

(2) Independency of data, that is, data description is independent of any hardware and software. CSG-based model data can be exchanged to XML data directly by data mapping.

Mapping method is as follows:

Firstly, a primary element is selected from those ones which construct a graphic object, and then it becomes a document element in XML document. The document element includes many other elements. Then the element of graphic body is expressed to XML element according to the mapping between CSG data structure and XML structure. Data mapping example is shown in Fig.2.

4 XML-based modular fixture graphs library system

To standardized library (SL), the description of parts document information based on XML is a relatively easy application. The SL will be more perfect to be used by heterogeneous enterprises platforms if the SL core--the graphics information of parts can be described by XML.

XML-based modular fixture graphs library system is made up of following sub-systems including XML template, XML data producing, XML data management, XML data processing and CAD data interface.

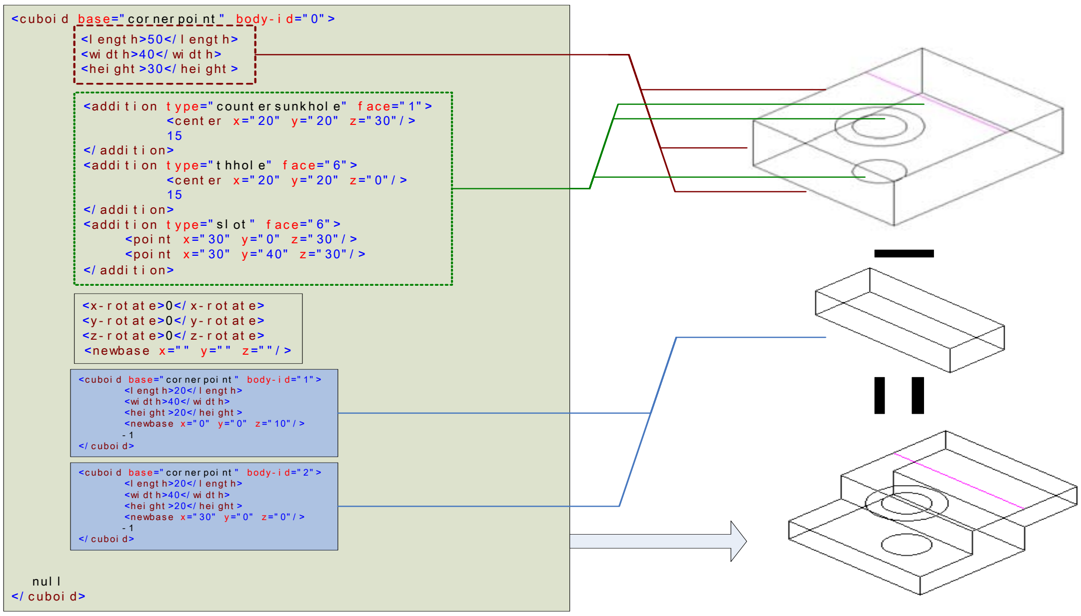

Fig.2. Data mapping example

(1) XML template sub-system

XML template is used to manage and produce the data input by users which is corresponding to the same kinds of parts having different shape. By template, the standardized degree is improved and work of XML parser is simplified.

(2) XML data producing sub-system

This sub-system consists of two parts, one is the parameterization processing program which exchanges users data for relevant data of CSG models; the other is XML data producing program which calls the corresponding part template in XML template and fill data in XML document. Thus, a XML file is produced which express a concrete part information.

(3) XML data management sub-system

This module store the part information produced by the former sub-system according to database or file directory in order to reuse it.

(4) XML data processing sub-system

This part has a XML processor which takes data from XML file, providing data source for CAD system to produce graphs.

(5) CAD data interface system

This module deals with interface of XML data processing module and CAD interface of software which exchange the XML data to acceptable form of CAD system. The final aim is to produce graphics in CAD system. CAD interface is achieved by ObjectARX. The data can be input from (4) to modeling function to make a graphic. Data processing and the data flow are shown in Fig.3. The software architecture of modular fixture graphicslibrary is shown in Fig.4.

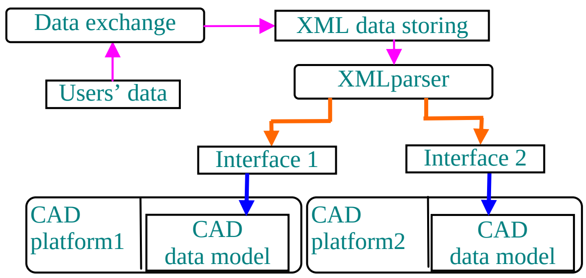

Fig.3. Data flow

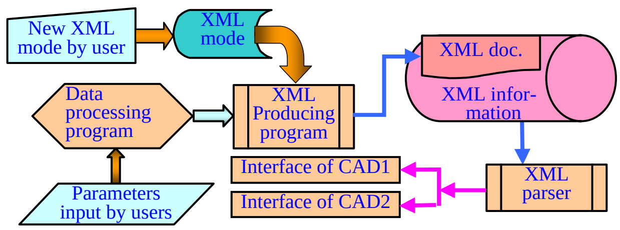

Fig .4.The software architecture

The workflow is as following:
a. Data structure of CSG model is mapped to XML document architecture by XML template;
b.Firstly, XML data producing sub-system transforms user's data to XML data and fill data into
d. XML data processing sub-system translates XML data into graphics data;
e. CAD interface sub-system takes advantage of the graphics data to produce graphics and the data are then simultaneously converted to CAD internal representation.

5 Conclusion

Modular fixture acts as flexible tooling in contemporary manufacturing system which plays a more and more important role in manufacturing process. MFGL is a crucial component of computer-aided fixture design (CAFD).So, how to reuse graphics library and make it independent of platforms is still an urgent problem. XML make it possible for MFGL to be used trans-platforms for its smaller data scale, higher exchange efficiency, platform independency and extensibility. The system application can be enlarged by introducing XML technology to MF configuration design system, and then the system can be independent of concrete CAD software and web-based information sharing and cooperative design will be much easier. From above research, that XML is applied to mechanical product design can bring reference to many other CAD systems to use XML-based technology. Thus, the application of professional CAD system trans-platforms can be improved. Although the main problem of the system had been solved, two problems still need to be improved, which are also the future work contents.

(1) To improve the automation of transforming graphics information to XML

Now when transforming graphics information to XML, models must be constructed by human, graphics data and XML architecture are also set up through semi-automation (half by computer and half by human). So, artificial intelligence can be taken into account in the process of the future modeling. Automatic programs should be developed in order to set up graphics data and XML architecture.

(2) To strengthen XML data management

In this system, the management of XML files is relatively simple. Database can be used to manage XML files, thus more data can be dealt with.

(3) Using Internet-based method to widen the system. To solve the problem of t data transfer and exchange trans-platforms, Internet-based method is a very

XML architecture, then, XML data file can be created;
c. XML data management sub-system is responsible for organizing XML data file;

effective method. However, most Internet-enabled fixture design systems presently only use the Internet as a medium for deployment and do not provide the functionality of the standalone systems [13]. There are fewer researches solving the problem. So, more concerns about it will be carried out in our further researches.

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