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Development of an Open BIM-Based Korean Traditional House Component Library Using an XML Parametric Information Approach

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Abstract With the rapid development of computer technology and ongoing destruction of traditional buildings, more and more attention is paid to digital methods for the design and preservation of traditional buildings. Unlike 2D methods, Building Information Modeling (BIM) provides an object-oriented and parametric digital representation way for traditional building components. However, one of the main limitations currently is that parametric information cannot be exchanged between BIM software packages. Therefore each kind of software must have their own parametric library which causes extensive works.

In this research, the authors developed an open BIM-based library using an XML parametric approach to solve the above problems, represented traditional components according to an XML schema, and parametrically implemented these XML files in a browser which can be accessed by users for their easy component edit and selection. And then based on the XML file of one component, implemented an Add-on in ArchiCAD for users to parametrically edit and directly utilize. Thus based on these XML files, a browser for users' view and selection purpose and an add-on for users' application purpose were developed. Future research will focus on implementing these XML files in other BIM tools like Revit and Digital Project. If the whole library was to be completed based on this XML approach, an open BIM-based library would be established that all kinds of BIM software users could apply this parametric library for easy modeling of traditional houses.

Keywords: Open BIM, Parameter, XML, IFC, Traditional Component Library

1. INTRODUCTION

1.1 Background

As the scale of building design becomes larger and more complicated, no single application can support all of the tasks associated with building life-cycle production, data exchange appears more important accordingly. In this sense, there have been numerous efforts on the development of specifications for data exchange and sharing in many industries. In particular, international efforts to the data exchange specifications resulted in the development of DXF or IGES. However, the data exchange remains restricted, since it is based on a fairly low semantic level of a document-based exchange of information like geometric representation and achieved only limited development that provides interfaces among commercial software (Fowler, 1995).

Since that, modern Computer Aided Design (CAD) systems generate feature-based product shape models with parameterization and constraints. However, the data exchange among different CAD systems was still restricted to the exchange of pure shape information in the context of the current technology. Meanwhile, recently more and more attention is paid to digital methods of design and preservation on traditional architectures. Unlike traditional 2D method, Building Information Modeling (BIM) provides an object-oriented and parametric digital representation way for traditional building components, an object-oriented 3D library can be established and users need only to adjust the pre-defined parameters to their own needs in order to apply this method to their projects directly. However, recent research mostly focuses on specific software, such as a 3D parametric library for Chinese Qing Dynasty carpentry that has been developed by the parametric tool Geometry Description Language (GDL) of ArchiCAD (Tan, 2006), and similar study has been performed by digital project (Yeun, 2009). These studies are limited to specific software packages; the parametric information cannot be exchanged among these kinds of BIM software (Eastman, 2007) even by open standard Industry Foundation Classes (IFC), which is called popularly to implement Open BIM. This means if users are to establish a library in BIM software A, the option to use parametric information from this library is unavailable to BIM software B using the current technology.

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1.2 Research Objectives and Methodology

In this research, the authors developed an open BIM-based library to solve the above limitations. Open BIM means using advanced tools to manage a collaborative, interdisciplinary workflow process without limiting users' choice of the electronic design and communication tools used (Peter, 2010). Nowadays, some open standards such as IFC and XML can be easily implemented and extended for the data exchange purpose. In this research, the authors developed an XML parametric approach for the Open BIM-based library which could be used in different BIM software packages. Figure 1 is the scenario of this research and the dotted rectangle shows the contents that will be elucidated in this paper. The authors leant experience from Korea Advanced Institute of Science and Technology (KAIST), which used a macro-parametric approach to transfer parametric objects in the mechanical field, used their XML Schema to represent the traditional components, the XML approach forms the core part of this research. Based on this XML approach, the authors implemented a browser for users' preview purpose. This browser will be implemented on web later which can be easily accessed by users. Then the authors developed an add-on for the direct utilization of the XML files in ArchiCAD. Future research will focus on developing add-ons in Revit and Digital Project for the direct utilizations of the XML files separately.

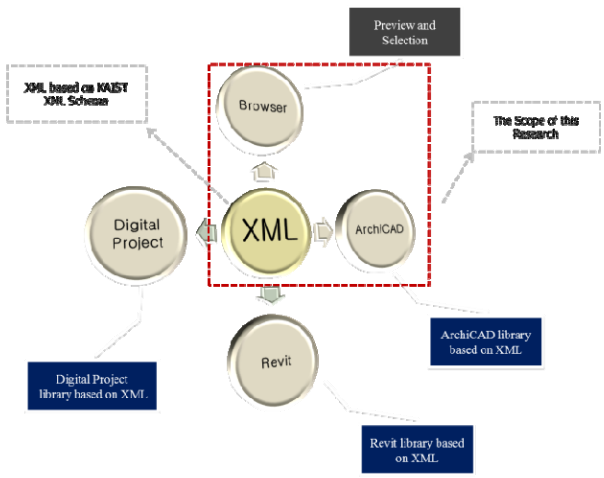

Figure 1. Scenario of XML parametric approach for Open BIM-based library development and scope of this research

Table 1. XML schema specifications (Mun *et al.,* 2003)

COMMAND	XML Schema	Attribute Definitions
POLYLINE	<xs:element name="SKETCH_Create_2D_Polyline"> <xs:complexType> <xs:sequence> <xs:element name="result_object_name" type="xs:string" /> <xs:element name="points" type="cartesian_point" minOccurs="2" maxOccurs="unbounded" /> </xs:sequence> </xs:complexType> </xs:element>	result_object_name: the name of a created entity points: series of points that are connected end to end.
EXTRUDE	<xs:element name="SOLID_Create_Protrusion_Extrude"> <xs:complexType> <xs:sequence> <xs:element name="result_object_name" type="xs:string" /> <xs:element name="profile_sketch" type="xs:string" /> <xs:element name="flip" type="xs:boolean" /> <xs:element name="start_condition" type="end_type" /> <xs:element name="start_depth" type="length_measure" /> <xs:element name="end_condition" type="end_type" /> <xs:element name="end_depth" type="length_measure" /> <xs:element name="selected_surface" type="xs:string" minOccurs="0"/> </xs:sequence> </xs:complexType> </xs:element> </xs:sequence>	result_object_name: the entity name of an extrusion. profile_sketch: the sketch name used to profile. flip: TRUE to flip direction to extrude, FALSE to original direction to extrude. start_condition: condition of the start face end_condition: condition of the end face end_depth: the end depth of Extrude.
CUT_EXTRUDE	<xs:element name="SOLID_Create_Cut_Extrude"> <xs:complexType> <xs:sequence> <xs:element name="result_object_name" type="xs:string" /> <xs:element name="profile_sketch" type="xs:string" /> <xs:element name="flip" type="xs:boolean" /> <xs:element name="start_condition" type="end_type" /> <xs:element name="start_depth" type="length_measure" /> <xs:element name="end_condition" type="end_type" /> <xs:element name="end_depth" type="length_measure" /> </xs:sequence> </xs:complexType> </xs:element>	result_object_name: cut instance name. profile_sketch: sketch name. flip: TRUE to flip direction to extrude. start_condition: start face's condition start_depth: start depth of Cut Extrude. end_condition: end face's condition end_depth: end depth of Cut Extrude.

2. AN XML PARAMETRIC APPROACH FOR OPEN BIM-BASED LIBRARY DEVELOPMENT

2.1 Definition of XML

XML is an international standard for electronic document exchange, optimized for the internet. It is a form of eXtensible Markup Language (XML). It also is a cross-industry development, and platform independent and non-proprietary (Marshall, 1999). It is practically one step removed from Hypertext Markup Language (HTML) and provides a facility to define tags and the structural relationships between them.

2.2 Advantages of XML

With the increasing popularity of XML in the distributed environment, mapping CAD model data into XML shows great superiority to make CAD models more accessible through the Web. XML is a widely accepted format for data exchange and is suitable to the open data implementation of application software. The use of a single standard within one company is inconvenient for users. A company may disappear, in which case the users of this standard face big loss. Due to these potential risks, there is strong demand for the deployment of open standards like XML-based standards (Seo and Kim, 2004).

In this research, the XML schema command and structure using to represent traditional house components are similar to the GDL script structure, which provides a potential way to map these two scripts and collaborate among BIM software. Besides, one of the final deliverables in this research is a web-based browser, and the XML approach provides the convenience for the implementation.

2.3 XML Schema Reference

To define a parametric library, there must be a standard applied. The parametric information cannot be exchanged by the current technology, so the authors studied experience form KAIST. In their study, after analyzing the commands in some mechanical CAD systems, a set of 144 standard modeling commands has been defined using XML schema, including 57 sketch commands, 40 solid modeling commands, 23 surface modeling commands and 24 constraint commands, then this XML schema is used as a neutral format to represent components in mechanical field (Yang *et al.,* 2004; Choi *et al.,* 2002). The history of user commands is recorded in a macro file, and the macro file is used for a static model exchange. In this paper, the authors applied this XML schema to represent the Korean traditional components in architectural field.

2.4 Standard XML Schema Specification

In the architectural field, the macro function in some BIM software differs from those in the mechanical field. Therefore it is difficult to apply the same approach in the architectural field. The authors applied the XML schema to represent the traditional components and implemented a browser and an add-on in ArchiCAD based on this XML approach. However, only some specific commands from this XML schema have been successfully used and implemented. Table 1 is the commands used in this research and their specifications (See Section 3.1 for more detailed utilization methods).

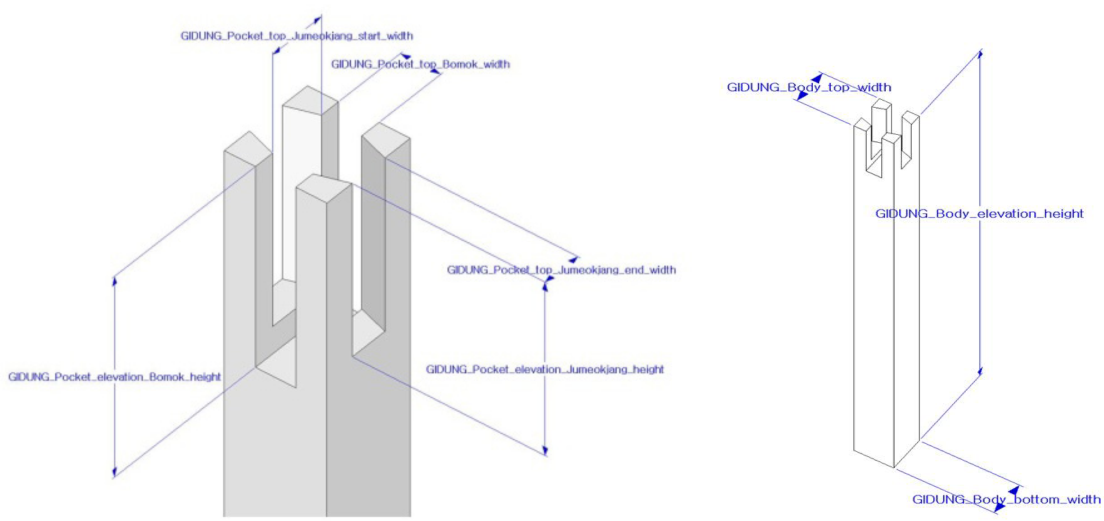

Figure 2. Traditional house column “GIDUNG” and its geometric parameters

Table 2. Abbreviation and default values of the parameters (Chon, 2010)

Parameter Name	Abbreviation	Default Value
GIDUNG_Body_top_width	GDa	165
GIDUNG_Body_bottom_width	GDb	165
GIDUNG_Body_elevation_height	GDc	2700
GIDUNG_Pocket_top_Bomok_width	GDd	65
GIDUNG_Pocket_elevation_Bomok_height	GDe	330
GIDUNG_Pocket_top_Jumeokjang_start_width	GDf	90
GIDUNG_Pocket_top_Jumeokjang_end_width	GDg	60
GIDUNG_Pocket_elevation_Jumeokjang_height	GDh	285

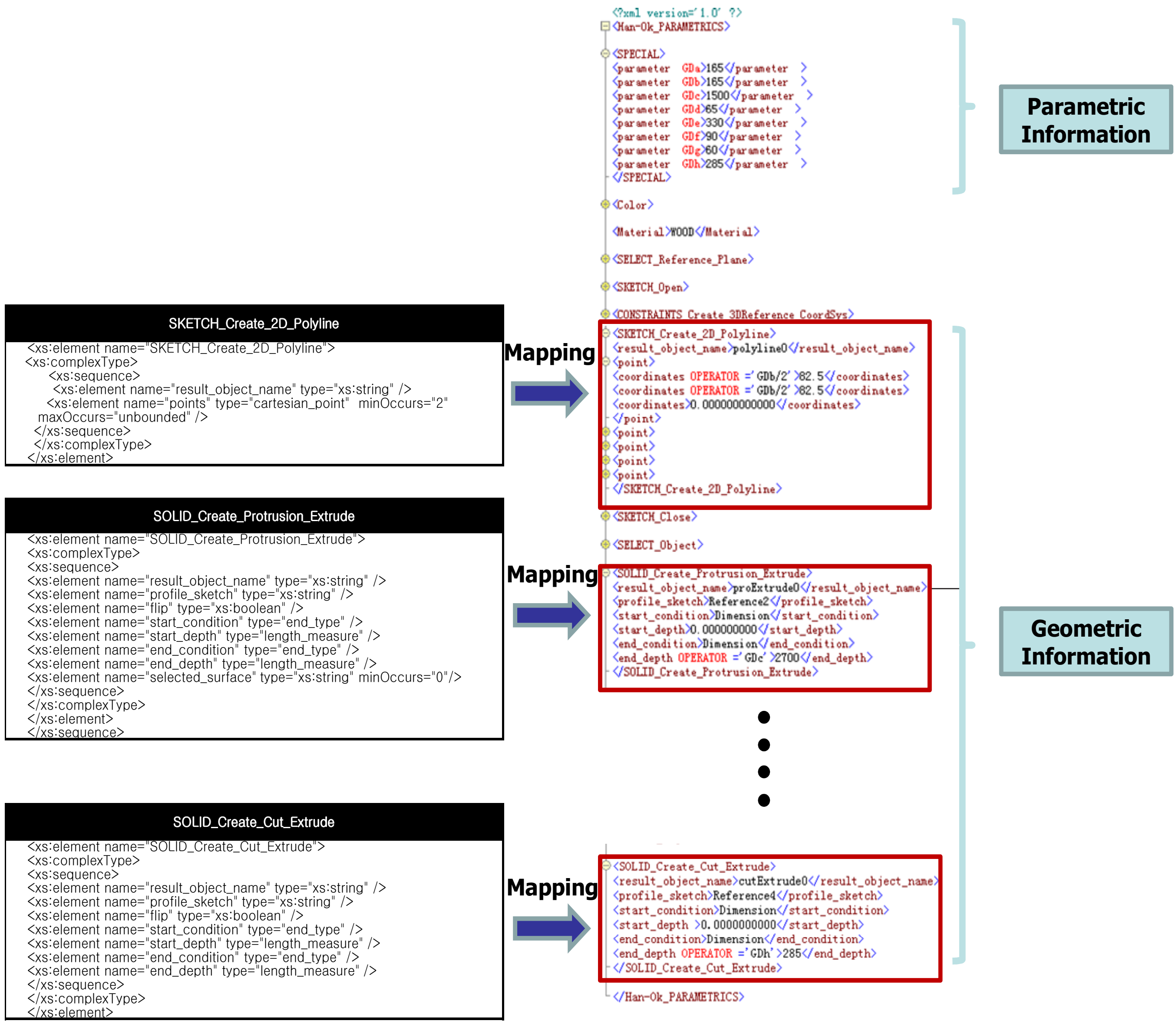

Figure 3. XML representation of traditional house column "GIDUNG" and its mapping relations

3. KOREA TRADITIONAL HOUSE COMPONENT REPRESENTATION

3.1 XML Schema Representation of "GIDUNG"

Figure 2 is a traditional house column call "GIDUNG" and its geometric parameters. Table 2 is the abbreviation and default values of the parameters, all the parameter names and the default values are defined by Prof. Bonghee Chon (Chon, 2010). The authors are going to use this column as the object to specify how to use the schema showed in Table 1 to represent the traditional components. Figure 3 illustrates the XML representation (right) of the component "GIDUNG" and its mapping specification of the XML schema commands.

As shown in this representation picture, the top right defines the parameter information and the default values of geometric shapes, the bottom right defines the geometric information, in the geometric definition part, the authors use "polyline0" as the name of the polyline, which mapped to the "result_object_name" in the schema of "SKETCH_Create_2D_Polyline", then five cartesian points with their coordinates are used to map the "points" in the schema, all of these represent a rectangle as the bottom profile of the component; then use "proExtrude0" to form the 3D cylinder, and use "polyline1" to represent the cut profile, finally the authors use "cutExtrude0" to represent the 3D cutting part. The structure of this XML file strictly corresponds to the left XML schema part.

3.2 Irregular Shape Representation

As mentioned above, only some specific commands have been successfully used and implemented. Therefore, only some components with regular geometric shapes can be represented by the XML approach. Our current solution for irregular component representation is to model them in the BIM authority software and export the information to IFC files, and then add some necessary information into these IFC files and use them to represent irregular shape components. However, these irregular shape components can only be adjusted by scale but not all geometric parameters later.

4. IMPLEMENTATION AND TEST CASES

4.1 Implementation

4.1.1 Browser Implementation

Based on the XML and IFC definition approach, a browser, which is a prototype system was implemented for users' component preview and selection purpose as shown in Figure 4, this browser was implemented by C++ programming language on the platform of Microsoft Visual Studio 2005, and the graphic data access engine is CASCADE.

This browser consists of several parts, including the "Main Property Window" at the top left part, which allows users to access the main properties of the project, "Editable Parameter Setting Window" (XML Attribute) at the bottom left side which allows users to adjust the parameters and related properties (defined by the XML files stated in the above paragraph), in the middle part is the "3D Browsing Window" which allows users to have a 3D view of their selected components, the top right is the "XML Tree View Window" which allows users to view the XML-based commands that are used in their projects, the left bottom is the "Library Tree View Window". This browser allows users to select their needed components by name and have previews at the bellowing window.

4.1.2 ArchiCAD Add-on Implementation

The authors referred to the Software Development Kit (SDK) tool from ArchiCAD system (Graphisoft, 2008) and implemented an XML import module, the module is used to parse the XML file to map the GDL script structure and import it into the BIM system.

After parsing the XML file, a pilot User Interface (UI) was implemented by C++ programming language on the platform of Microsoft Visual Studio 2005 for this component "GIDUNG" as shows in Figure 5.

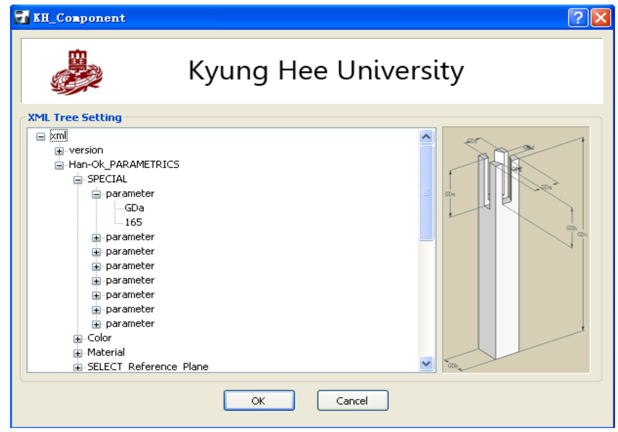

Figure 5. User interface implemented in ArchiCAD

Users need to import the XML file of "GIDUNG" before running this interface. As shown in this UI, the commands which defined in the XML file were implemented with a tree structure.

The left part of the UI is the "Tree Window", which allows users adjust the parameters. At the current stage, only the geometric shapes can be parametrically adjusted, the other parameters such as color and material will be practiced in the future research. The right part of the UI is the "Profile Window", which allows users to make certain of what the parameter means. After adjusting the parameters to users' will, click the "OK" button and insert the object or click the "cancel" button to cancel the operation.

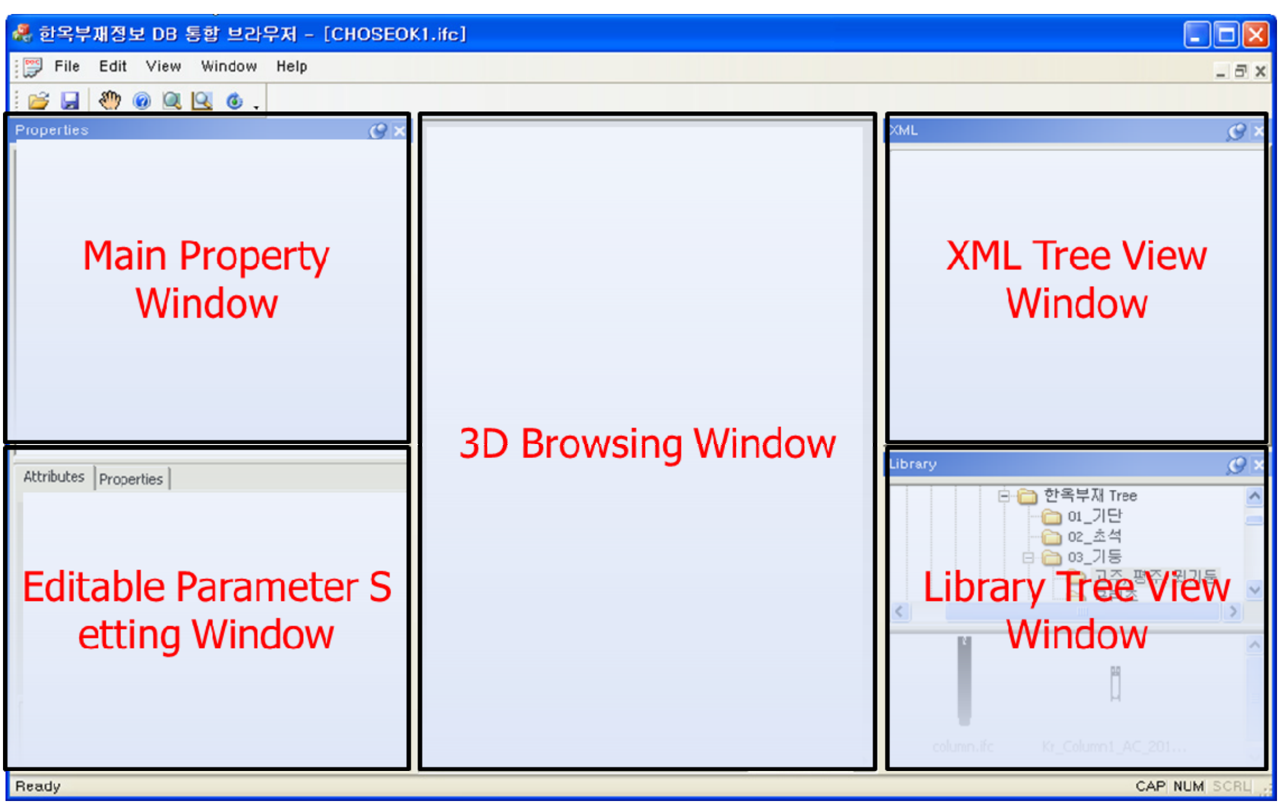

Figure 4. Open BIM-based traditional house library browser

One of the main objectives of this research is to solve the interoperability problem of parametric information, so the UI needs to support parameter adjustment function.

Users have two ways to adjust the parameters here, one is to adjust the parameters in the XML file and import into the UI, and the other way is to import the XML file with its default values and adjust the parameters by the UI.

When adjusting the parameters in the UI, both the corresponding values of XML and GDL change simultaneously, however, the changed XML file cannot be exported thus far, how to export the changed XML file will be practiced in the future research.

After the parameter adjustment, the object can be inserted into ArchiCAD, and then users also can adjust the parameters in the property window supplied by ArchiCAD (Specifications are given in Section 4.2.2).

4.2 Dimension Change in Browser and Column Insertion in ArchiCAD

4.2.1 Dimension Change in Browser

The component import and 3D view function will be tested, and the function that the geometric shape can be parametrically adjusted will also be tested. In this test, the authors will select three components in the browser, see their 3D previews, and choose one of them, adjust the parameter values to see the 3D changes.

As shown in Figure 6, three components were selected in the Library Tree View Window, their parameters and 3D views are available, and as shown in Figure 7, the height of the "GIDUNG" changes from "2000" to "2500", the geometric shape changes correspondingly. Users could have previews on their needed component with proper size. Later this browser will be implemented on web for users' easy accession. After confirming the component with proper size users need, they could go to the specific BIM software to apply the components directly.

4.2.2 Column Insertion in ArchiCAD

The XML import function will be tested, and the function that the geometric shape can be parametrically adjusted will also be tested. In this test, the authors will use three different test processes to prove the add-on in ArchiCAD was well implemented.

The three different test processes are:

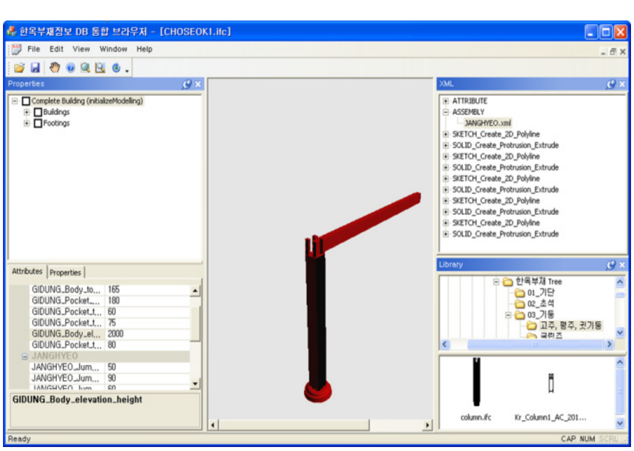

Figure 6. Component selection and preview in browser

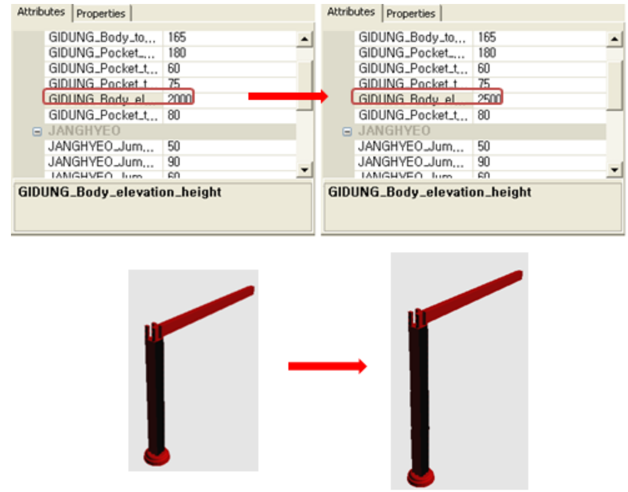

Figure 7. Geometric shapes change as parameters change

(1) Remaining the Default Parameter Values and Inserting Object

Figure 8 shows test case 1. In this case, the parameter values remained as default in the XML file, import the XML file by clicking the add-on named "KH_Component" which is the abbreviation of "Korean House_Component", remain the default values as well and insert the object in ArchiCAD, the object appears with its default parametric values.

(2) Adjusting Parameters in UI and Inserting Object

Figure 9 shows test case 2. In this case, the parameter values remained as default in the XML file, import the XML file, and then change the value "GDc" which is the height of the component from "2700" to "4000" in UI, insert the object, and the height of the object is "4000" can be confirmed.

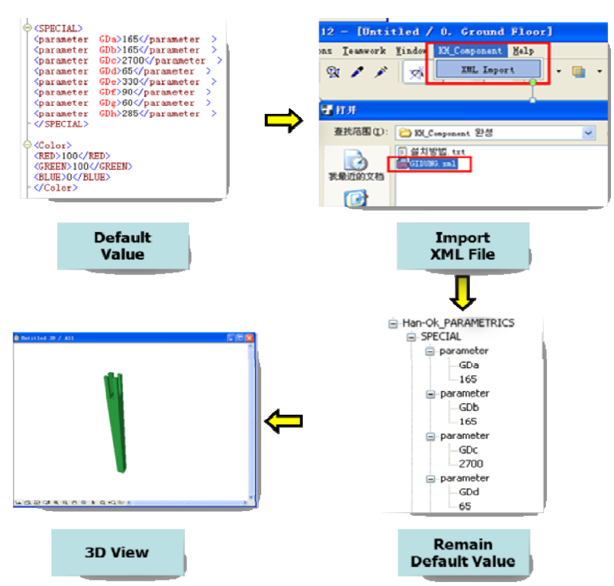

Figure 8. Diagram of test case 1

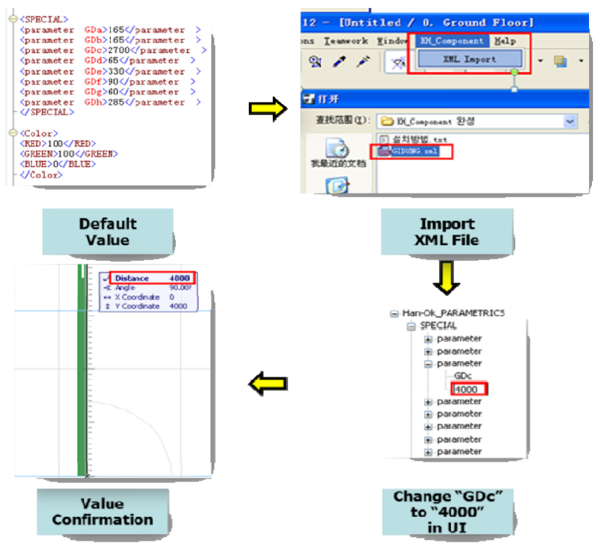

Figure 9. Diagram of test case 2

(3) Adjusting Parameters in XML File and Inserting Object

Figure 10 shows test case 3. In this case, first change the parameter value "GDc" from "2700" to "1500" in the XML file, import the XML file, and the value "GDc" in UI appears as "1500", then insert the object, and the height of the object is "1500" can be confirmed.

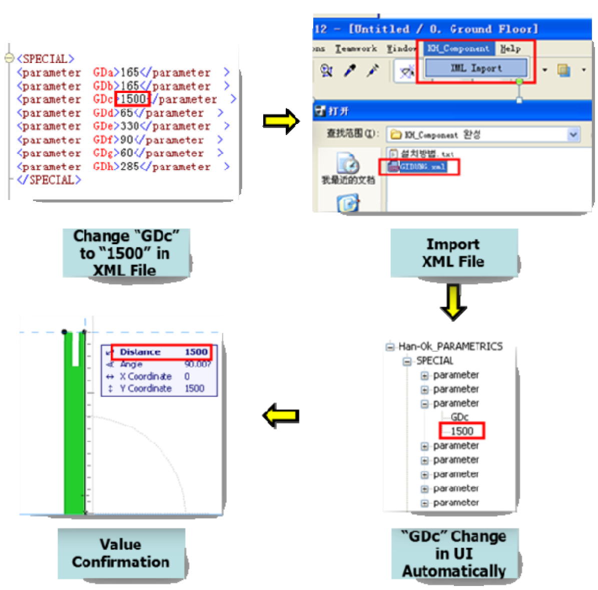

Figure 10. Diagram of test case 3

5. CONCLUSIONS

In this paper, a new method to develop the open BIM-based library was proposed. Specifically, in this study, the authors applied an XML schema from the mechanical field and took it as a vocabulary to represent the traditional components in parametric ways. Because this XML-based technology can be easily implemented in distributed environment, based on this XML parametric approach, the authors implemented a browser which can be easily accessed and allow users to select and preview on their needed component, and then implemented a pilot add-on in ArchiCAD, which allows users to import the XML files, adjust the parameter and insert object directly in ArchiCAD. It shows the feasibility of the XML parametric approach used for open BIM-based library establishment. From the test cases, we also can see that the add-on can be applied to utilize the XML library directly for the application of the object.

The remaining limitations of this research are that only some specific commands from the XML schema have been successfully utilized and implemented, so it is necessary to implement more commands from the XML schema to represent various types of traditional house component shapes. Meanwhile, the XML files of the traditional components are manually typed which causes masses of works, so the authors are going to develop a translator to map the geometric information from IFC files to XML files automatically. The authors only implemented a test add-on for one component in ArchiCAD, so complete the add-ons for all of the traditional component utilizations in ArchiCAD is needed. After adjusting the parameters in the add-on user interface, the changed XML files cannot export for other usages, so it is necessary to develop a module which can export the changed XML files for a circulated usage of the library as well. Finally, as the feasibility of the XML-based approach has been confirmed in a browser and ArchiCAD, future research on the add-on development of other BIM software package such as Revit and Digital Project is important.

If all the works stated above were to be finished, an XML-based parametric library would be established which allow all kinds of BIM software users apply the open BIM-based library directly in their projects.

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