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A 3D DOCUMENTATION SYSTEM FOR THE KOREAN TRADITIONAL WOODEN STRUCTURE

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Abstract. A Korean traditional wooden structure is constructed under specific rules of assembly and proportion. Thus, the geometric dimensions of a wooden component as well as the proportional relations between the components can be parameterized. This paper will propose a new documentation system of Korean traditional wooden architecture using ObjectARX.

1. Study Background

The Korean traditional wooden structure has its unique way of both constituting and determining the dimensions of each component. The dimensions of wooden components are proportionally constrained with each other. It is possible to figure out the key dimensions of each component and the dimensional relationships between the components of an assembly. The analysis of the key dimensions and their relationships makes it possible to build an efficient modeling tool for Korean traditional wooden structures.

Users of the proposed program may be students, designers or managers of Korean traditional buildings. They can record geometry and other related data about a building, and if necessary they can develop their own applications using the proposed product model.

2. Composition of the Korean Traditional Wooden Structure

A Korean traditional wooden structure is composed of hundreds of components which are assembled into higher level assembly units in a successive manner. The components are constrained with each other in terms of dimension and location. In this paper, components and assemblies are uniquely defined because of the differences in their inner property.

2.1. A COMPONENT

2.1.1. Class Definition for Component

A component class contains the information about component types, geometries, location, connecting parts, etc.

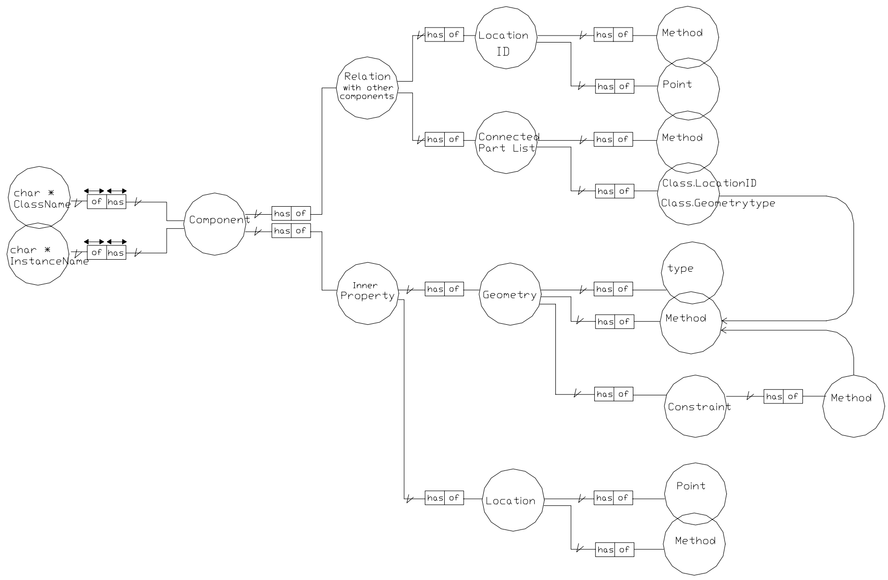


Figure 1. NIAM of a component

A Korean traditional wooden structure has more than 20 classes components and each of them has several variations as component types. This component type is the smallest module that works as a unit. The more component types can be derived from a class, the better modeling of a wooden structure can be achieved. In this paper, component classes are classified as follows.

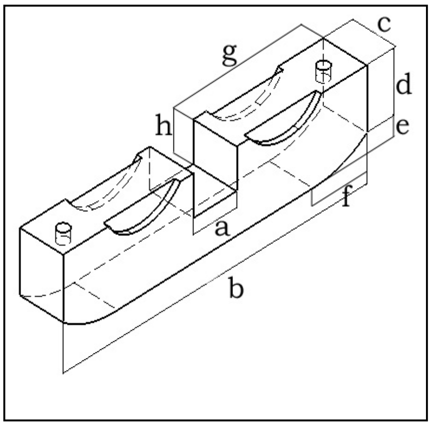
TABLE 1. Component class types.

CLASS	SUB CLASS
DOO	Judoo, Soro
GONG	Chumcha, Jegong, Dugong
JOO	Kidung, Dongjaju
BANG	Changbang, Pyungbang
RYANG	Daeryang, Toeryang

DOREE	Yoimokdoree, Naemokdoree, Jungdoree, Jongdoree
BOO	Jangyou, Danyou
CHUNYOU	
YOUN	Jangyoun, Danyoun, Booyoun

2.1.2. Parametric Dimensions of a Component

As proportionally constrained, the dimensions of each component in a Korean traditional wooden structure are determined in a unique way. There exists a key dimension of a component that determines the other dimensions of the component. For example, the width of Chumcha is the key dimension that decides the value of other dimensions proportionally. (Figure 1.)



	proportion		mm
a	a		120
b	7a		860
c	a		120
d	1.25a	1.65a=i	150
e	0.4a		45
f	1.125a		138
g	3a=(b-a)/2		370
h	0.825a=0.5i		97.5

Figure 2. The parametric analysis of chumcha.

As wooden components are assembled into larger assembly units, the dimensions of a component are also proportionally constrained by those of other components.

The width of a Chumcha that determines other values of Chumcha has the same value with the width of Jegong. Connected components share the same dimension that works as dimension constraints.

Though the parametric technique supports an easy and fast component modeling, it is also important to implement a way of representing the slight deviation of component dimensions. Even though buildings share a rule of proportion, they cannot but differ in details because they are handmade artifacts that have been made through thousands of years by numerous carpenters. So the function of modifying dimensions is necessary in documentation system.

2.1.3 Variations of Geometry

The geometry of a class may have its variations. A class of Soro has at least 4 types of variations in geometry. These variations are predefined in the class Soro and one can assign the type of geometry while making an instance of a Soro class. On the other hands, geometry can be post-defined as a class Soro after a user draws the shape of a component. This post-defined geometry is required as a method to represent non-parametric variation of geometry.

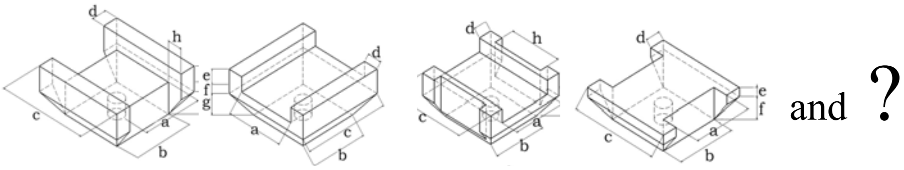


Figure 3. Soro variations.

2.1.4. Connection of Components

The joining methods are designated according to the geometries of the joining pieces of two corresponding components. Most components in Korean traditional wooden structures are assembled without connecting steel nail. The connecting parts of a component are shaped to make a tight and solid joinery with that of the corresponding element. A mortise and tenon joint has been used the most frequently in Korean traditional wooden structures.

A mortise and tenon joint has lots of variations, but all the variations of this joining method can be generated in the process of generating. Different joint types are classified as shown in table2.

TABLE 2. Joint types.

AmB	An end of one component fits into the corresponding socket of another connecting component.
AmBp	A projecting piece of one component fits into the corresponding socket of another connecting component and a mortise and tenon joint.
AmBm	Both components are cut off to make a joint.
AmCBm	Both components are mortised and a clamp is inserted to connect both components.
AB	Two components simply come in contact without joinery articulation.

There are two different cases in joining components. One is that the geometry of a component is defined before it is located on the site and the other is versus. Most of components are the former case.

Another case is that the geometry of a component is defined when it is located on the site. The joint between Jucho(stone base) and a column is representative. The bottom of column is cut according to the joining surface of a Jucho and this makes tight connection between two components. For this kind of connecting method, the program needs a module to update the geometry of a component according to the surface of a connecting component.

2.2. AN ASSEMBLY

2.2.1 Class Definition for an Assembly

An assembly class has a list of components that can belong to it. A Gongpo assembly has component list of Judoo, Chumcha, Soro, Dugong, Jegong.

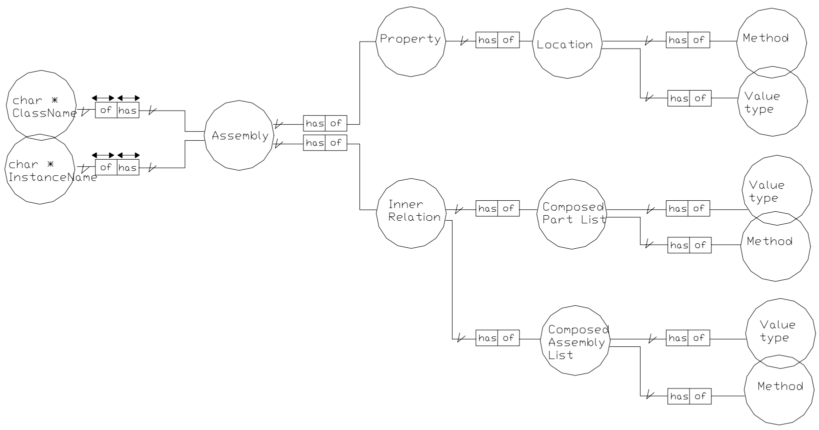


Figure 4. NIAM of an assembly.

An assembly class has a list of possible components and the instances of assembly components are generated in consideration of the joint point. This class has location constraints among components.

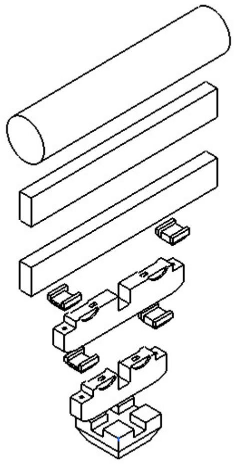


Figure 5. Part of GongpoAssembly.

Table 3 lists types of assemblies and belonged components.

TABLE 3. Assembly types.

	COMPONENTS
Column assembly	Kidung,Changbang, Pyungbang
Gongpo assembly	Judoo,Chumcha,Soro, Dugong, Jegong
Roof assembly	Chunyou, Jangyoun, Danyoun, Booyoun, Daeryang, Toeryang, Yoimokdoree, Naemokdoree, Jungdoree, Jongdoree, Jangyou, Danyou

2.2.2. ON SITE VS. OFF SITE

Most of components are manufactured near a building site and assembled together in short time on the site. Assembling components means the change of insertion points of the components. Though internal dimension constraints are designated off the site, external dimension constraints, or offset distance of components are applied on the site.

The components of a small assembly such as those of Gongpo are composed into an assembly off the site and then transferred to the location of the building site. This means the insertion points of the components change twice, from random point to relative offset point among components, and to final insertion point on the site.

3. Application

The documentation system is built with Object ARX, the customizing API of AutoCAD.

3.1. COMPONENT GENERATION

Each component is generated at random location with the input value of the key parameter dimension. Other dimensions have default values that are determined by the proportional relationships with the key dimension. Though the location of this phase is off the site, each component has the location ID as a member of an assembly. The location ID works as a constraint. The height of column with corner location ID is larger than the height of other columns.

The predefined connecting type can also be recorded in the process of component generation.

3.2. ASSEMBLY GENERATION

A Column and a Roof assembly are generated in the course of deploying the instances of component types on the site. A Gongpo assembly is initially generated by the deployment of the components off the site, and then the insertion point of Gongpo is finally designated when this assembly is transferred to the site.

The post-defined connecting type is now recorded after the geometry of the component is modified on the site.

3.3. LINK OF VARIOUS TYPES OF DATA

One can record the name of carpenter and the date of modeling, and other types of documents such as photos or word files can be linked to the model of a building.

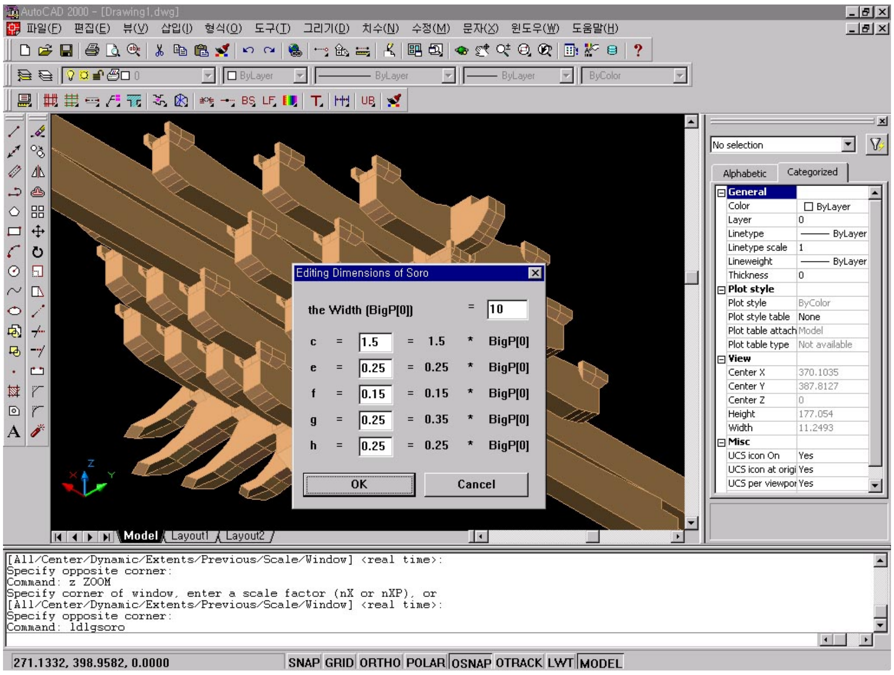


Figure 6. Modifying dimension.

3.4. EXPORTING TO DATABASE

One can save the generated data - dimensions, connecting types with other components and assemblies, related files, and etc. - in a database. This enables various analysis with the tools supported by database programs.

4. Conclusion

Components and Assemblies are respectively defined as two major classes. for modeling a Korean traditional building. A component class has dimensional constraints, geometry types, a list of connecting components, and a location ID as a member of an assembly. An assembly class has a list of components and their location constraints.

The capability of dimension modification is adopted to accommodate the slight deviation of component geometry. And the post-defined geometry is added to be able to represent non-parametric variations of component geometry.

This application will facilitate the understanding of the specific rules of Korean traditional wooden structure, as it allows users to modify the dimensions of a component geometry in condition of its typological character.

So the educational effect is quite promising. The propsed 3D modeling and documentation of Korean traditional wooden structures will be useful to the designers and the contractors of Korean traditional wooden structures.

Acknowledgements

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