AUTOMATIC 3D MODELING OF KOREAN TRADITIONAL ARCHITECTURE

Applying Parametric Design

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Abstract. Korean traditional structure is constructed as prefabrication jointed in largely characterized by its unique components under the specific rules of assembly and proportion. This point is a double-edges sword. Because, while various shapes and sizes of components based upon an objected-oriented form appear the potential possibility of producing changeable prototypes to build up, these various characters of components and several jointed methods has made difficulties to handle. Accordingly, an automatic 3D modeling algorithm is focused on the methodology of changeable prototypes of Korean Traditional architecture keeping traditional jointed methods with setting various characters of components

Keywords. Korean traditional structure; Parametric design; Generative three dimensional modeling; Hanok.

1. Introduction

The traditional architecture of Korea is a building made by connecting components and components. Because of this characteristic, the connection method between the various components plays a very important role. However, it is difficult to easily describe how to connect its components. In addition, to make understanding of architecture easy, it should be made into three-dimensional drawing, not two-dimensional drawing. Through these works, we will be able to facilitate modernization of the traditional architecture and reinterpret traditional architecture. It also needs to simplify the way of connecting architectural elements with architectural elements in terms of modernization and explores various forms derived from traditional architecture to give insight to architects. From this point of view, this study shows how three-dimensional models can be automatically generated and how traditional architecture can be transformed from a modern point of view. In this case study, this paper deals with the Daengung-jeon of Sudeoksa Temple
is jointed with various components. This complicated structural performance has
been only taken to few craftsmen with 2D drawing. Accordingly, it has led a typ-
cical formation and performed time-consuming process from unmanageable diver-
sity of components’ types and relationship. However, in the context of the digital
era, parametric design provides a new approach to architectural methodology of
Korean traditional architecture. For this approach, a sample of Daengung-jeon of
Sudeoksa Temple which is an oldest wooden building in Korea is utilized. The
whole scale of Daengung-jeon of Sudeoksa Temple (19,152mm x 13,195mm) is
set as a maximum size, and the distance and angle between component and com-
ponent are constrained. In the process of the study, two methods are proposed.
First is a bottom-up method assembling from the smallest component composed
of the building. And second, a top-down method is used for reconfiguring from
a form to component (Park 2011). In this paper, Grasshopper is applied for func-
tional relation between components by automatically calculated process. In this
study, a correlation between components applying structure function relationship
is essential (Kwon 2014). It also leads on an automatic formation of Korean tra-
ditional architecture keeping relationship between components as well as makes
time efficiency on the process (Stavric 2011) The objective of study is to establish
parameter networks involving the correlation between components and develops
a parametric algorithm for the automatice generation of 3D model of the Korean
traditional architecture based on parameter networks.

2. Literature Review

Korean Traditional structure is constructed as a free-form building jointed in
largely characterized by its unique components under the specific rules of assem-
bly and proportion (Ahn 2011). Thus, the geometric dimensions of a wooden
component as well as the proportional relations between the components of a part
assembly can be parameterized (figure 2).
2.1. VARIOUS CHARACTERS OF COMPONENTS
While various shapes and sizes of components based upon an objected-oriented form appear the potential possibility of producing changeable prototype to build up, these various characters of components and several jointed methods have made difficulties to handle.

2.2. BUILD ONLY FEW CRAFTSMEN’S INSIGHT
In addition, the wide characters of components have been dealt by only few craftsmen’s insight with 2D drawing. A natural interaction is characteristic of this tool which can be considered by hand work. This condition has supported more difficulties to make the system for generalization (Kim 2010).

2.3. 2D DRAWING
As follows, the drawing is not a smart medium, but rather, a code based on standards and conventions. This 2D drawing has two limits. First, the act of drawing differs from cognitive mechanisms underlying the creative process. It is just like recording. Second, the drawing process excludes physically relevant aspects that in the real world drive the generation of forms (Tedeschi 2012).

3. Research Method
Simulation research is applied as a research method. It is useful both developing and testing theory, and simulation occurs when a replication of a real-world contains within it dynamic interactions that are the result of manipulated factors. Based on simulation research, the flow diagram shown in figure 3 was conducted.
4. Hierarchical Relations of Components in Bracket Unit

In the figure 4, the number of components is classified into the layer with its name because one of key features of Korean traditional structure is that the architecture builds on bottom-up system. At Level 1, a column as a vertical component is set. In addition, at Level 2, a beam as a horizontal component is jointed. From Level 3 to Level 6, the “Bracketing Unit” part is formed in total balance by crossing the horizontal components and the vertical components in figure 4. Figure 5 illustrates the characteristic of components, and how the different shapes of components assemble each other following the rule of Korean traditional structure.

![Figure 4. Hierarchical Classification of components based on the level.](image-url)
5. Variations of Spatial Configuration Using Parameter Relationships Between Components.

Figure 6 shows the network among elements of each component in Korean traditional architecture. The depth and width of the whole scale and the height of the column are set as independent variables. In addition, all remaining components are set as dependent variables; the height of the lowest column has a function relationship with the height of others. In addition, the depth and width of the whole scale has a correlation with the depth and width of all the components. On the other hand, specific components having the shape of a cube and a cylinder have the same value of depth and width. (Kim 2010) Therefore, the specific components of depth and width have parameter relationship with depth and width of the whole scale at the same time. In brief, depending on the component’s shape and position, the number of variables is different and parametric relationship between components is defined.

5.1. AUTOMATIC 3D MODELLING BASED ON PARAMETER NETWORK

The parameter relationship network (figure 6) is a foundation to set up the algorithm to create automatic 3D model system. Figure 7 shows the algorithm to produce a 3D model automatically using the relationship between components of “Bracketing Unit part”. When the numerical value of one variable is raised, the numerical values of remaining variables are automatically raised according to parametric relationship. In other words, when one component’s dimension extends, the dimension of all remaining components are automatically extended. As mentioned earlier, the problem of modernizing Korean architecture is how to handle with many components efficiently keeping the joint system. Accordingly, the algorithm suggests automatic modeling methodology by parameter relationship between components.
Figure 6. Parameter relationship network.

Figure 7. The algorithm according to the functional relationship between components.
Based on the algorithm, figure 8 indicates the parametric relationship between components. All columns’ 3R are followed by the value of a width or the depth of whole size. In addition, the height 1 of a column called Pung-Joo has parameter relationship with others’ height. Figure 9 shows parameter relationships between a column and a beam.

Since Korean traditional architecture is constructed by joints of members and members, it is very important how to connect the members. In order to show an example of joint method between components and components, the method selected in this paper is a method of connecting columns and beams. Chang Bang, a kind of beam, is a horizontal component that connects a column to a column at the top of a column. Figure 9 shows how the columns are arranged and connected to the Chang Bang. The width and depth of Chang Bang is inter-related to width and depth of all upper components. Figure 9 shows the results depending on the applying the functional relationship between components or not. Figure 9 (a) shows unmatched connection between components with no functional relationship.
and figure 10(b) figures out the connection applying the functional relationship between components. In this way, to create a natural joint between the component and the component, a function that reflects the relationship between the parameters needs to be used.

In the similar way of modeling a column and a beam, we can produce various structures obtained applying different parametric value of components using the parameter relationship network (figure 11).

Figure 10. Comparing joint part. (a) non parametric relationship (b) parametric relationship among components.

6. Conclusion

The paper suggests an automatic 3D modeling methodology for the process of Korean traditional architecture. In order for traditional wooden architecture to make harmony with the environment and culture of modern society, the process to build up Korean traditional architecture has to be flexible and efficient (Park 2009). This study has attempted to deal with the difficulties of 3D modelling of the traditional architecture and demonstrated how to apply algorithmic parametric design to produce automatically 3D models. This algorithm for an automatic 3D modeling that combine digital technology with traditional building system can conduct the potential possibility of traditional architecture that was previously impossible to realize because of technical shortage in the past. In addition, for modern people living in a different environment and society from a past, the methodology with algorithm of a study shows some suggestions of exploratory space derived from formal changes of traditional wooden architecture. Therefore, this an automatic 3D modeling method provides a starting point for the evolution of the process for modernization of Korean traditional architecture.
Figure 11. Various forms explored applying different parametric value of components.
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References


