John S. Gero, Scott Chase and Mike Rosenman (eds), *CAADRIA2001*,
Key Centre of Design Computing and Cognition, University of Sydney, 2001, pp. 265-274.

THE WOODEN CONSTRUCTION DATA MODELING OF KOREAN TRADITIONAL ARCHITECTURE

Focused on the structure of Gongpo in Buseoksa MuRyangsujun

JIN-WON CHOI, HYUN-SOO LEE, JIE-EUN HWANG AND MI-JUNG KIM
Yonsei University
Korea

Abstract. Finding national identities from its traditional heritages might be an important research issue especially for Asian architects and researchers. Nevertheless, it is noticed that the structure of Korean traditional architecture has not been fully explored in a systematical or computational manner and its information is not shared efficiently. This study thus explores a computational way of structuring construction knowledge and building information of Korean traditional architecture. To do this, we select a well-known old temple building, Buseoksa Muryangsujun, one of the oldest Buddhist temple in Korea, as a prototype. We first build an accurate three-dimensional model of the building with an aid of a traditional building expert, categorize its building components, and then analyze their connectivity and the connectivity patterns and rules by especially focusing on the capital order system, called Gongpo. The result of the study shows several schema diagrams representing the wooden construction data model carefully designed for an intelligent building simulation and generative system that will be developed in the near future. The paper also demonstrates a way of computationally describing some shape grammars that explain the components' connectivity.

1. Introduction

New trends for this millennium require both globalization and localization at the same time. The new paradigm of localization requires local and national identities that have frequently been ignored during the modern industrial era of the last decades. Finding national identities from its traditional heritages might be an important research issue especially for Asian architects and researchers.

Korean architects couldn't have many chances to learn from their traditional architecture during the period of the nation's fast industrial development. It might be a right time to study and learn their ancestors' wisdom from the traditional building systems. It is quite timely in the sense that current emphasis in this field is on sustainable and ecological aspects of the building systems. A deep investigation of the wooden structure of Korean traditional architecture would give a concrete foundation to develop such systems.

Nevertheless, it is noticed that the structure of Korean traditional architecture has not been fully explored in a systematic or computational manner. And also its information is not shared efficiently even though the technology for sharing information effectively, such as the Internet, is quite available and the shared information could be used in many application areas. Currently only few experts keep their knowledge exclusively and limitedly transfer it to others in a traditional manner. One of the reasons is due to the inheriting way of traditional architecture relying on the traditional craftman's man-to-man way, rather than a more systematic way. So it is not so easy to approach the information of the Korean traditional architecture even for architecture students and experts. Another reason is related to the problem of media with which the information is incorporated. Korean traditional architecture is based on the wooden construction complicatedly assembled by prefabricated components. But the current media for the most architectural information consist of 2D drawings, inadequate to present prefabricated 3D components and their complex joints. 2D drawings limits to, above all, indicate the joints and relations among the components, so it is almost impossible to understand correctly the whole construction process only referring to them.

This study thus explores a computational way of structuring construction knowledge and building information of Korean traditional architecture. To do this, we select a well-known old temple building, Buseoksa Muryangsujun (Figure 1), one of the oldest Buddhist temple in Korea, as a prototype. Buseoksa Muryngsujun is known for the second oldest building among the existing Korean traditional wooden buildings, and has never been renovated before. Thus it represents the orthodox form of the Korean Traditional wooden structure. We first build an accurate three-dimensional model of the building with an aid of a traditional building expert, categorize its building components, and then analyze their connectivity and the connectivity patterns and rules by especially focusing on the capital order system. Like the Greek order system, the Korean order system, called Gongpo (Figure 2), is both structural and ornamental, and plays a key role in constructing the wooden structure.

Figure 1. The exterior view of Buseoksa Muryansujun.

Figure 2. Gongpo, the capital order system, in Muryangsujun.

The data model we are developing will be used in a tutoring system of Korean traditional architecture, called KotaView (KOrean Traditional Architecture VIEWer).

2. An Overview of KotaView

KotaView is a tentative name of a web-based tutoring system of Korean traditional architecture we are currently developing. Even though navigation is a main feature in the system to experience the structure of Korean traditional architecture with 3D objects similar to the real world, we want the system to be smart enough to understand the wooden structures. So an indispensable premise is an existence of a robust data model, which understands building components, the connectivity between components, and their connectivity rules.

In terms of basic operations, users can select a building component classified in some categories, and then simulate it to observe the shape of the component and the way it is connected to others within the whole structure.

The conceptual interface of the web-based system is composed of five main parts: 1) a main menu frame to contain the subjects of the whole system, e.g. preferences, lectures, courses, boards, etc.; 2) a sub-menu bar to contain complete categories to classify the main menu items; 3) an embedded viewer to show the real-time simulation of the construction, one of the key modules of KotaVew; 4) a movie player to show interactive movies including the information of constructions; and 5) a prompt window to show real-time messages.

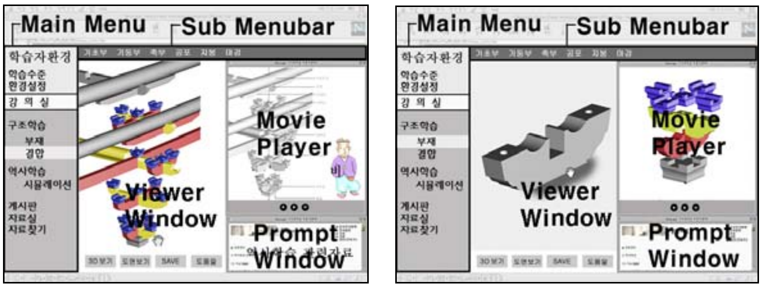

Figure 3. The conceptual interface of KotaView.

3. The Construction Data Modeling of Gongpo

3.1. THE ANALYSIS OF THE GONGPO STRUCTURE

The component shapes composing a Gongpo do not always correspond to the names and types. Some components have different names or roles each other with an identical shape, while some have a same role with different shapes. Thus it is more efficient to create a shape-type for each shape. A list of shape-types will construct a database for component shapes.

After listing up the component shapes, we unfold all of the components in a Gongpo and analyze them by the construction orders. There could be some repetitive rules in the connecting orders such as in Jegong. In general, a Gongpo is composed of a Judu, Jegongs, Chobangs, DanJangyeos, and JusimDories. (Figure 9) A Jegong is a sub-structure composed of repetitively layered subsets such as ChoJegong, YiJegong, SamJegong, and SaJegong. Each Jegong is also made up by a repeated rule of assembling. Now we develop several schema diagrams representing all the components and sub-structures with the connecting rules. (Figure 4, 5, and 6)

Table 1 presents component-types, shape-types, names, and the terms used in the diagrams.

TABLE 1. The shape-type list.

Component -type	Shape-type		Name	Terms used in the diagrams
Judu		ShJuduA	WeojinjuJudu	Judu
Chumcha		ShChumchaA	SoChumcha	S_Chumcha
			ChulmokChumcha	CH_Chumcha
			SalmiChumcha	P_S_Chumcha
		ShChumchaB	DaeChumcha	L_Chumcha
			JusimdaeChumcha	J_L_Chumcha
			SlamidaeChumcha	P_L_Chumcha
Soro		ShSoroA	YangalSoro	SoroA
		ShSoroB	NegalSoro	SoroB
Jangyeo		ShJangyeoA	TeunJangyeo	T_Jangyeo
		ShJangyeoB	DanJangyeo	D_Jangyeo
Bo		ShBoA	TeuBo	T_Bo
Chobang		ShChobangA	Chobang	Chobang
		ShChobangB		
Dori		ShDoriA	JusimDori	J_Dori
			ChulmokDori	CH_Dori

3.2. TYPES OF COMPONENT SHAPES

Figure 4 is a diagram featuring the types of component shapes. The lines represent the composition hierarchy. Components are presented in gray color and sub-structures or groups of components in white. One component always has a single shape-type.

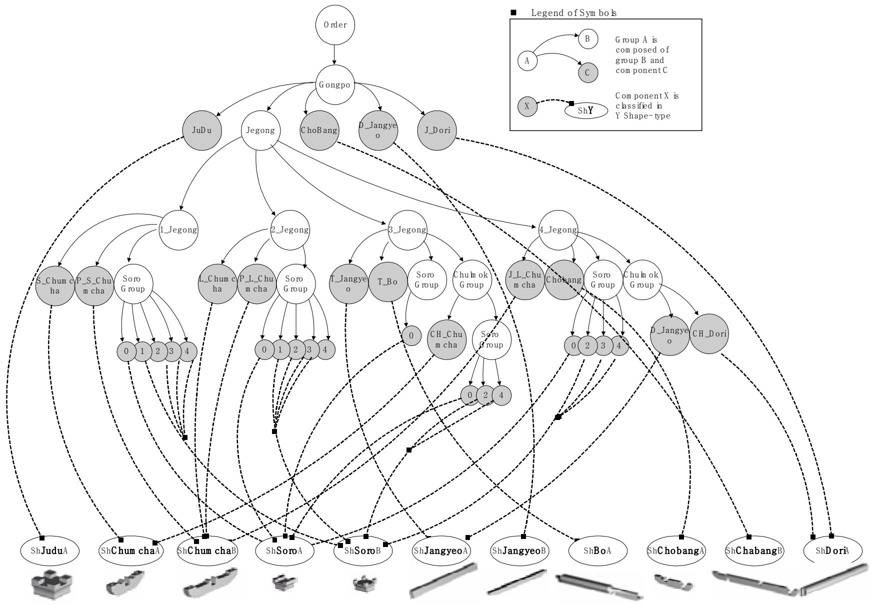

Figure 4. A schema diagram for types of component shapes.

3.3. TYPES OF CONNECTION ROLES BY THE ASSEMBLING ORDERS

While connecting a component to another component by the assembling order, we can recognize some components (or groups) acting as constructors that determine a primary structure, and the others acting as connectors that bind two constructors. The concepts of connectors and constructors would play a key role in generative rules for a later version of a Kotaview generative system.

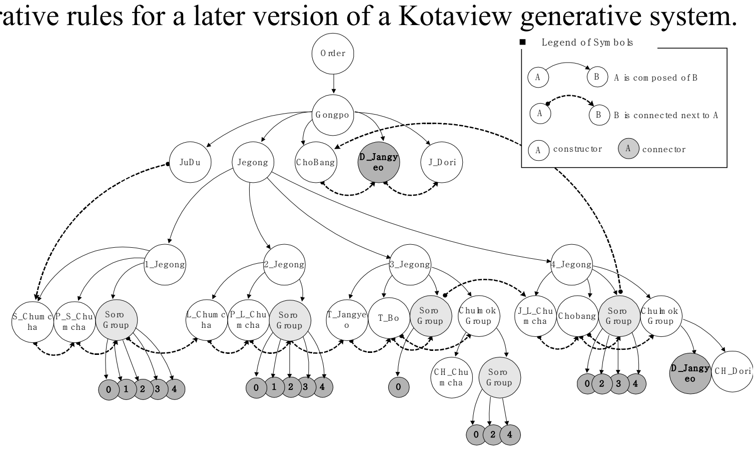

Figure 5. A schema diagram for types of connection roles .

3.4. TYPES OF RULES OF ASSEMBLING

In Jegongs we can particularly figure out the repetitive rules of assembling. A subset of Jegongs is composed of both Dori-directional and Bo-directional components, a Soro group evenly, and a Chulmok group occasionally. Figure 6 presents this rule.

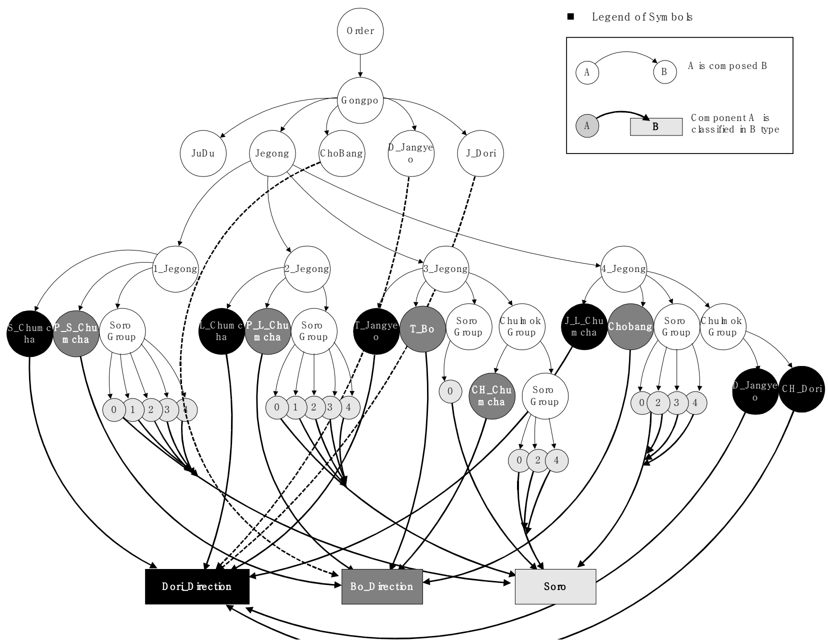

Figure 6. A schema diagram for types of the assembling rules.

3.4. THE CLASSFICATION OF COMPONENTS

After considering all the analyzed factors, we can classify the components of Gongpo (Figure 7). We develop possible component classes and investigate their dependencies on each other, and then link themselves to each other based on the rules already described above. This will be implemented to develop the KotaView system that manages the component databases of Korean traditional architecture.

Figure 8 shows the complex relationships between components (or groups) by the various notations of the paths and explains types of classes.

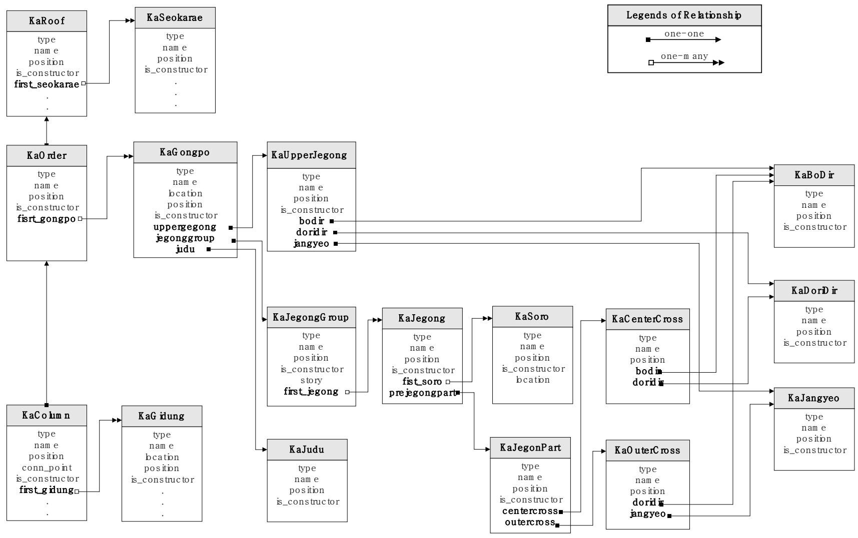

Figure 7. The classification of the components of Gongpo.

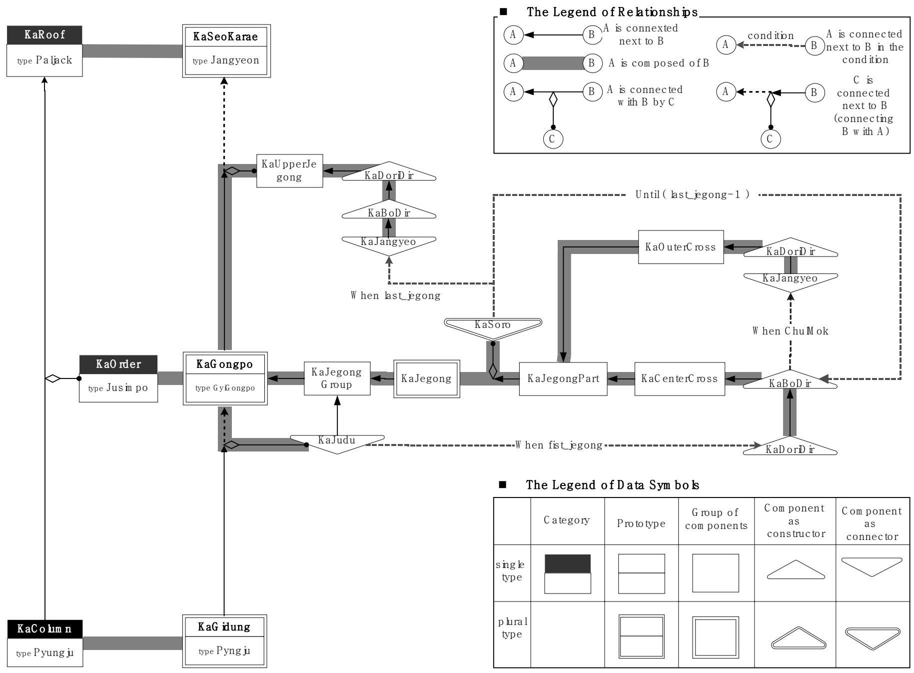

Figure 8. The relationships between the components.

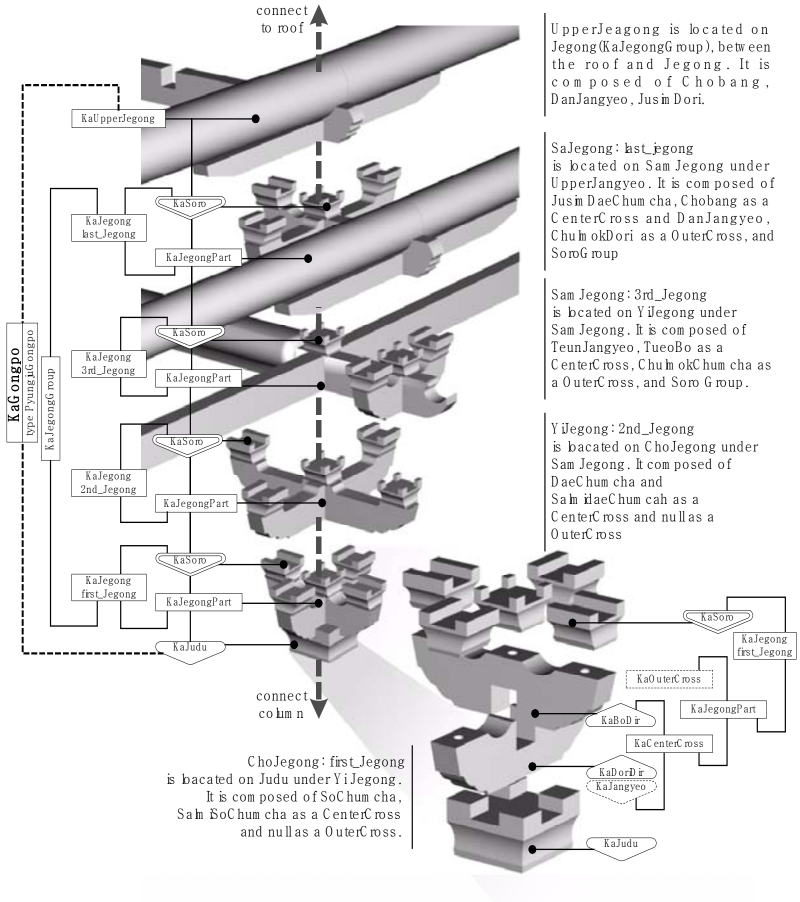

Figure 9. The whole feature of the Gongpo structure corresponding to component classes.

4. Conclusion

This study is to construct a robust data model in order to effectively and intelligently describe Korean traditional architecture. To do this, we analyzed and classified the components of the Gongpo structure. The Gongpo structure has logics of assembling components, and in turn each component has logics of defining shapes. The component shape is closely related to the connecting location and its role. Thus the logics can be organized in a systematic manner and can be extended to the shape grammars of constructing Gongpo structures.

5. Further Study

Further research issues identified are as follows: 1) expanding the data model to explain the whole building's structure, 2) developing a VR-based tutoring system to simulate the construction of Korean traditional architecture, and finally 3) developing a generative design system, which can intelligently generate a new type of wooden buildings that could actually be built.

We are currently under the process of developing a web-based solid modeler, called WebMod, that will be a main geometric engine of KotaView. We are also further investigating to develop other modules such as a movie player, databases, etc.

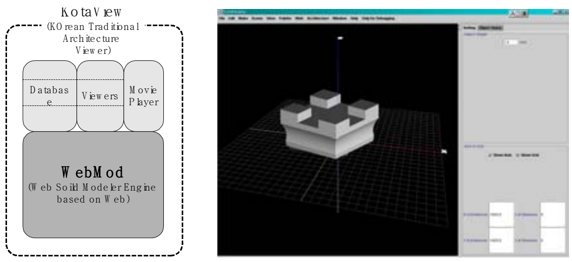

Figure 10. The system overview of the Kotaview modules and the WebMod prototype engine.

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References

Chang, G.I.: 1987, *Wooden Structure*, Bosunggak, Seoul.

Chang, G.I.: 1986, *Korean Traditional Architectural Glossary*, Bosunggak, Seoul.

Eastman, C.E.: 1994, A data model for design knowledge*, Automation in Construction*, 3, pp.135-147.

Kim, U., Choi, J.W., and Kim, S.A.: 1999, A house design automation system based on the “design-by novice”*, Architectural Research, Journal of the Architectural Institute of Korea*, **1**(1), 23-30.

Mitchell, W.J.: 1994, Artifact grammar and architectural invention, *in* Tzonis A. and White I. (eds), *Automation Based Creative Design*, , pp.139-159

Stiny, G.: 1994, The pedagogical grammar, automation*, in* Tzonis A. and White I. (eds), *Automation Based Creative Design*, pp.129-138.