Title:
The Integration of Procedural Information in Traditional Architectural Design on Perspective of Communication Theory

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Introduction:
Gao-chi is a bamboo pole which utilizes specially appointed symbols to record and integrate procedural information of carpentry work of ancient traditional architecture, as described in Fig. 1.. It plays an important role both in design and construction stage of traditional architecture practice in Southern Fujian of China [6]. However, the Gao-chi craft has gradually disappeared for some reasons including the promotion of design technology and industry collaboration, especially the labor division of design and construction. The gradual disappearance of Gao-chi craft results in the deficiency of procedural information, which leads to some embarrassing situation of low design quality in contemporary practice of traditional design, including disproportion of elevation, the error of tenon-and- mortise work and unreasonable bay etc.

Fig. 1: The procedural information is recorded and integrated into Gao-chi by specially appointed symbols.

With the promotion of information technology, more and more CAD technology are applied to practice of Chinese ancient traditional architecture, but which more is limited to application of BIM in the maintenance stage, and few are discussed about the design stage [7]. This study shows that regarding the perspective of communication theory, the generative modeling based on procedural information should record and integrate the necessary procedural information in the construction process as a design tool in contemporary design practice of traditional architecture. This modeling should integrate multi-disciplinary knowledge, reduce the knowledge gap between design and construction, and

improve communication efficiency. To illustrate the viewpoint above, a carpentry work model of traditional architecture in Southern Fujian is modeled using generative modeling. With the assistance of this building model, the contemporary architect should intuitively know the design and tectonic principles of carpentry work in the design process, just as craftsmen designed and constructed ancient buildings by Gao-chi craft. The model will also improve the design quality of traditional architecture design.

Main Idea:

- *Procedural information in traditional Gao-chi craft*

The construction of the traditional building in South Fujian follows a series of established rules of construction. Gao-chi records important information including geometry information and non-geometry information both in design and construction stage respectively [1][2], as the description in Tab. 1.. Among them, Shui-gua diagram drawing determines the key height and estimates the Ji-xiong size in rough section drawing (Fig. 1.). The Ji-xiong size means good or ill luck for the owner of building, which is an essential factor in Feng-shui culture of Chinese traditional architectural. And Gao-chi drawing mainly focuses on the design of components and details of nodes, as described in Fig. 2. [1]. Therefore, traditional craftsman can record this information by Gao-chi in design stage and apply it in construction stage, following the established construction rules of traditional architecture.

	Design		*Construction*
	Shui-gua diagram drawing	*Gao-chi drawing*	
Geometry information	Column position, Depth, Number of purlin, Distance between purlins, Roof slope, Roof radian	Height of ridged purlin, height of each purlin, eaves height, component size	The geometry information recorded by Gao-chi for stock preparation, lofting, checking and fabrication
Non-geometry information	Ji-xiong size, Construction taboo	Component location, Spatial relationship between components, Tenon-and-mortise work relationship between components, Consideration of Structure	The non-geometry information recorded by Gao-chi for assembling.

Tab. 1: The information recorded by Gao-chi in design and construction stage.

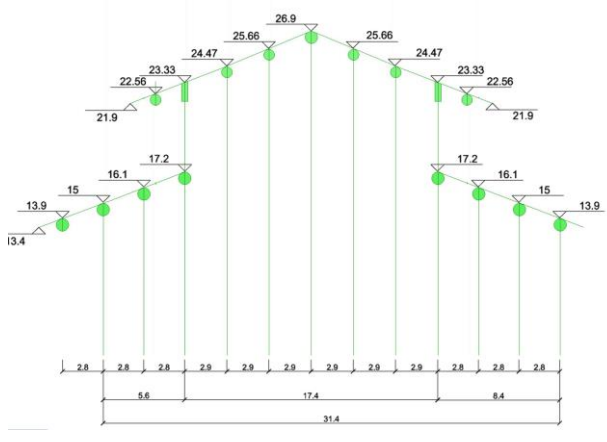

Fig. 1: Determination of key height by Shui-gua diagram.

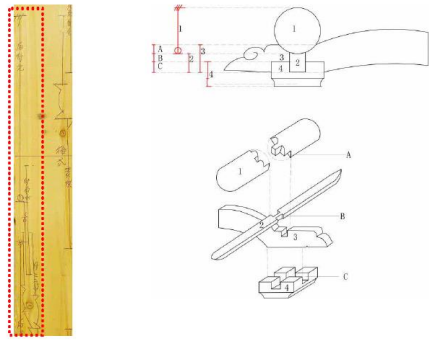

Fig. 2: Determination of the assembly relationship and size of components.

- *Generative modeling*

Different from conventional CAD technology which is based on declarative information to describe building form, generative modeling is a modeling technology which is based on the procedural information description [4]. GML(Generative modeling language) is a language represented by constructive graphics and takes the basic information unit as its constructive process to present complex three-dimensional models. It is more concerned about the process than how to generate a shape, and the shape is only a by-product of the program. There are two characters as follow: On the one hand, generative modeling can record the procedural information of design process in a systematized and structural way to trace and revise the design decisions in previous stage; on the other hand, it can maintain the requisite formal character in the revising process [6]. Therefore, the application of generative modeling in contemporary traditional architecture design process should integrate the geometrical information and procedural information to maintain the necessary formal idiosyncrasy of traditional architecture in the design process, thereby improving design eefficiency.

- *Communication theory*

Based on communication model proposed by Claude Shannon[3], this article propose two communication models between design and construction in traditional architecture design of Southern Fujian, which are based on Gao-chi craft and generative modeling respectively.

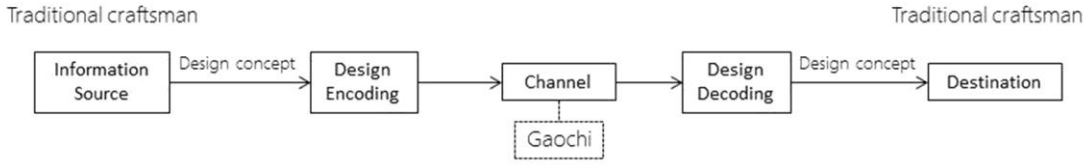

Fig. 3: Communication model between designer and constructor in traditional architectural design.

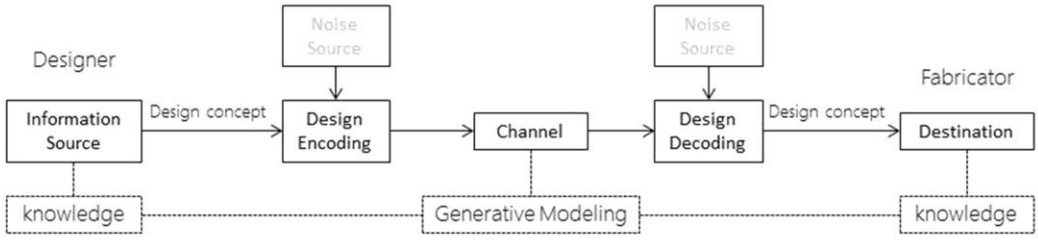

Fig. 4: Communication model between designer and constructor based on generative modeling.

Fig. 3 describes the communication model between designer and constructor who are all traditional craftsman. In this model, Gao-chi is the channel which transfers the design information encoded by designer to the constructor for decoding. Due to the designer and constructor are all traditional

craftsmen who have the same knowledge background, the influence of noise should be low in encoding and decoding. Therefore, the transmission of information is more fluent in the traditional architectural design process, thus, ensuring the design quality.

Due to the strict tectonic principle between wooden components are maintain in design process by Gao-chi, traditional architecture can maintain some kind of form. Similar to Gao-chi craft, generative modeling should record not only the geometry information but also the procedural information which include strict tectonic principle, even the construction taboo and Ji-xiong size. That is the multi-disciplinary integration of different knowledge backgrounds between designer and constructor. Thus, it should reduce the influence of noise in encoding and decoding to improve the fluency of information transmission. Fig. 4. describe the communication model between designer and constructor by generative modeling.

- *Illustration*

To illustrate this viewpoint, this study attempts to model a carpentry work of traditional architecture in Southern Fujian of China by generative modeling. It includes two parts which are Shui-gua diagram drawing and mid-section carpentry work modeling.

Firstly, Shui-gua diagram which include the size judgement of Ji-xiong affects the form of traditional carpentry work directly. Therefore, the algorithms related to Ji-xiong size is encoded and integrated into the model. Designer should regulate the key size of model which including planar size, height etc., and estimate the Ji-xiong size in the meantime, as shown in Fig. 5. and Fig. 6..

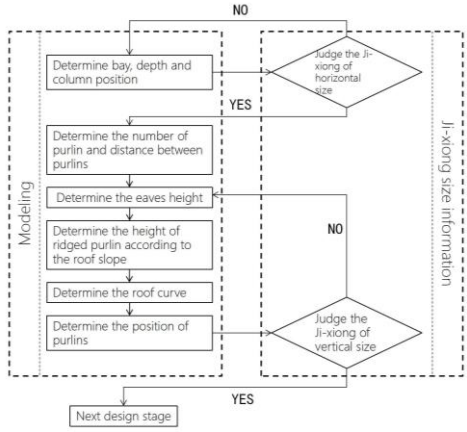

Fig. 5: Process of Shui-gua diagram drawing.

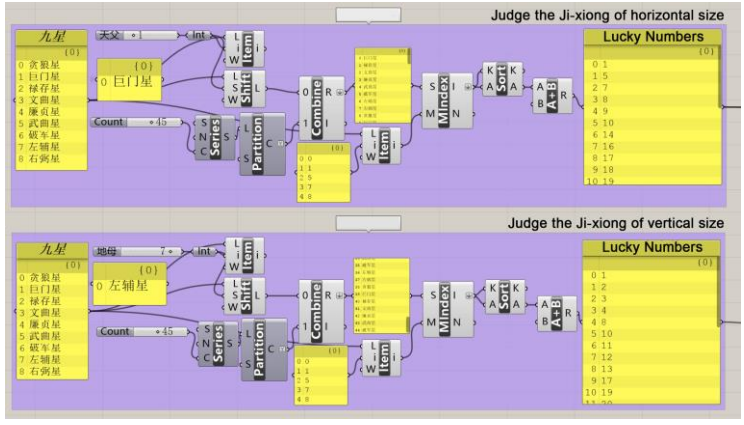

Fig. 6: The algorithm of judging Ji-xiong size.

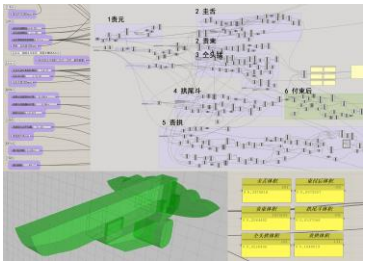

Fig. 7: The procedural information of component assembly can be integrated into model by generative modeling.

Secondly, the mid-section carpentry work is modeled as an example. The size of each component is recorded and feedback to designer as the reference in later construction stage for fabrication, cost estimation and assembly. The tectonic principle between components will be also recorded, as shown in Fig. 7.. Although the designer adjusts the component size, the mid-section carpentry work will also follow the tectonic principle.

In other words, designer should follow the estimation of Ji-xiong size and strict tectonic principle in design process to maintain the intrinsic nature of traditional architecture. Meanwhile, the formal features of traditional architecture will be preserved. In addition, all these procedural information integrated into model will be used as reference in maintenance stage.

Conclusion:

In the background of promotion of information technology, the generative modeling technology will revise the design model in an efficient way and maintain the requisite formal character of traditional architecture in a meanwhile. It should integrate the multi-disciplinary knowledge to improve the fluency of information transmission and reduce the communication gap between designer and constructor. In this process, the geometry information and procedural information are integrated into model to reduce traditional architecture cost and improve design quality.

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