

# 3D Reconstruction of Chinese Historical Architectures Based on Data Fusion and Parametric Modelling



## Abstract

Heritage building information modelling (H-BIM) integrates topological, geometric and semantic information of built heritages in digital representation, such as the structure, component types and quality defects, which improves the management of the protection, restoration and dissemination process. However, due to the unique and complex geometry of built heritages, reconstruction of an H-BIM model containing complete information is challenging. This study focuses on solving the technical difficulties in the 3D reconstruction process of built heritages, including point cloud classification and parametric modelling. A case study was carried out in the Suzhou Twin Pagoda. Photogrammetry and laser scanning technologies were used for data acquisition and measurement of the actual scale of the architecture. Based on historical design principles in *Yingzao Fashi*, various kinds of parametric components of the wooden structure were generated and then mapped onto the point cloud to become a complete model of the architecture.

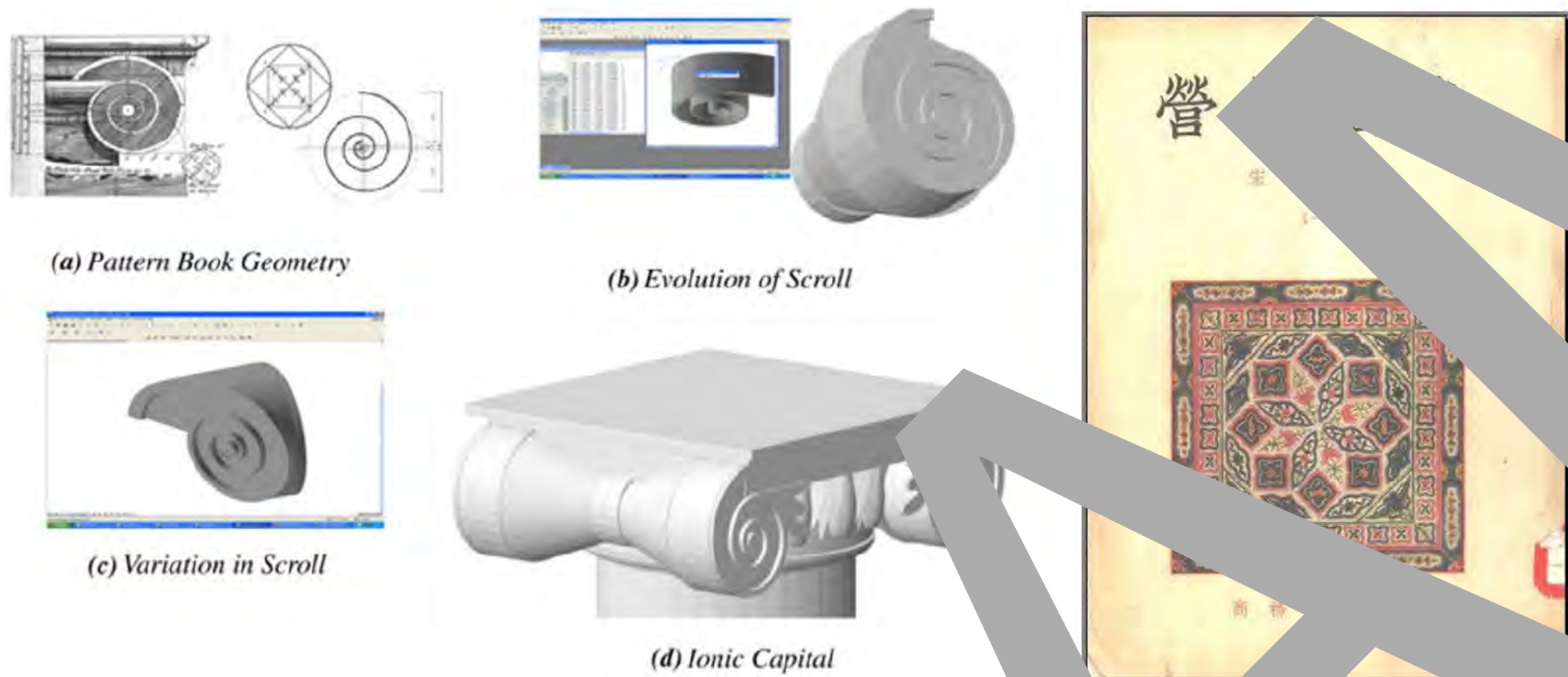
## Research Problems

Most current 3D reconstructions of Chinese built heritage only reproduce the geometric appearance but do not include the composition of components, which is of real value to architects and archaeologists for research and conservation. The reason is components of Chinese built heritages have high levels of irregularity and unique geometry, which bring many difficulties to the 3D reconstruction process.

## Methodology

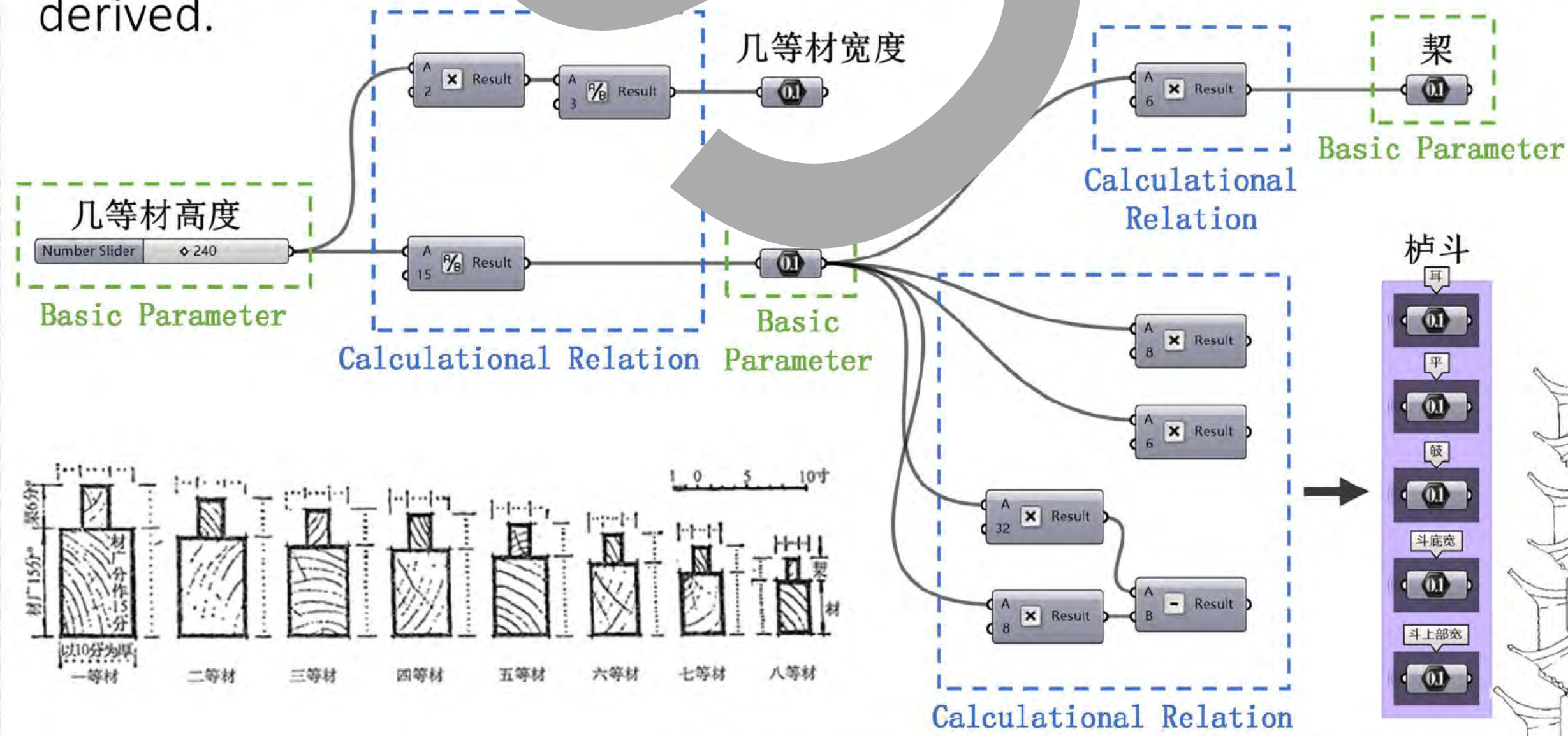
### Parametric Modelling in H-BIM

Parametric modelling is a process using design principles based on ancient manuscripts to construct parametric representations of architectural components, then establishing parametric library elements and finally mapping these elements onto the point cloud. Murphy (2009) introduced parametric modelling for Western built heritages, which improved the efficiency of 3D reconstruction and enriched the semantic information of the model.



### Design Principles of the Built Heritage - Cai-Fen system (Yingzao fashi (Song Dynasty))

The scale of a house and the proportional relationship between its structures is regulated by *Cai* and *Fen* (材分). The basic size parameters *Cai* and *Fen* are defined, and the parameters of each component can be derived.



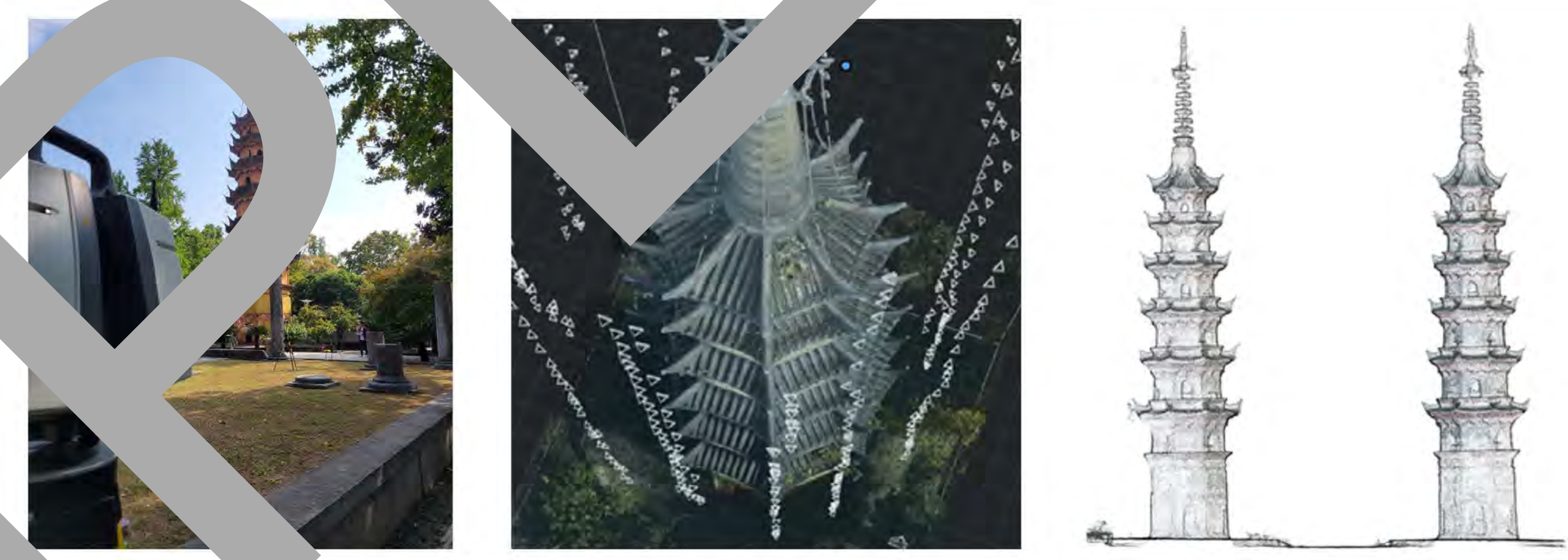
According to the historical design principles of *Yingzao Fashi*, the basic parameters *Cai* and *Fen* can be defined in Grasshopper, and then other following parameters can be derived.

Component types of the column top set (斗拱柱头铺作)	
昂	下昂为单材，长度一般为23分
泥道拱	长62分
华拱	长一般为72分
斗拱	长宽一般为32分，高度为20分。斗耳8分，斗平4分，斗欹为8分。开口宽度10分，深度8分。直径：殿阁柱两材两架至三材，厅堂柱两材一架；卷杀：柱长分三等分，最上一等分再分三等分，渐收至上径比斗底底各出4分。
柱	
“分”	1/15 材的断面高度为1“分”
“材”	以具体尺寸，具体比例定出八个等级的木材截面

## Aim & Objectives

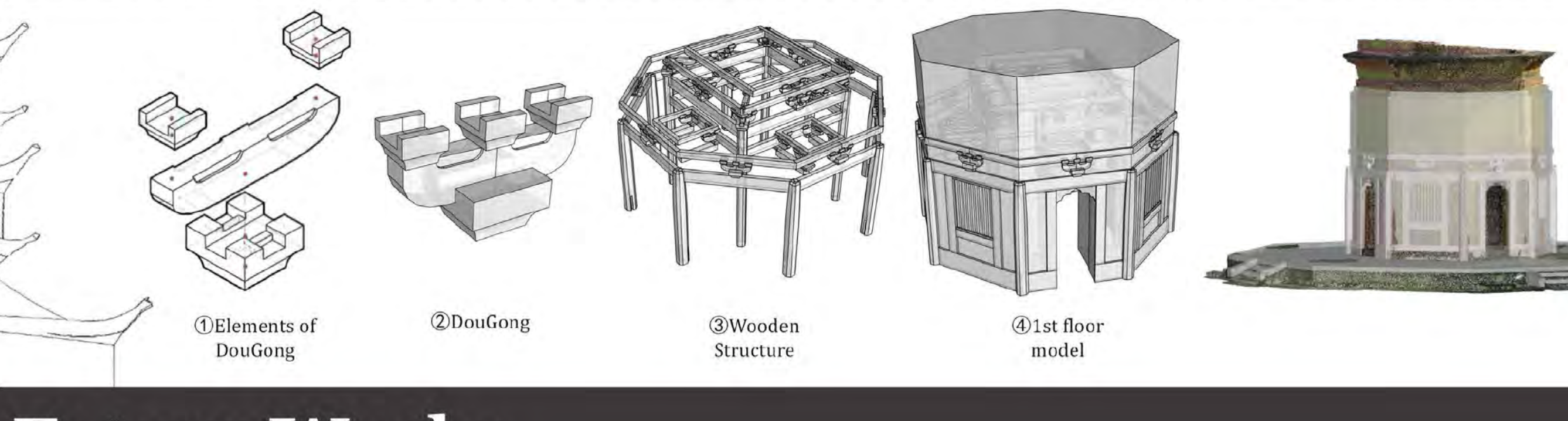
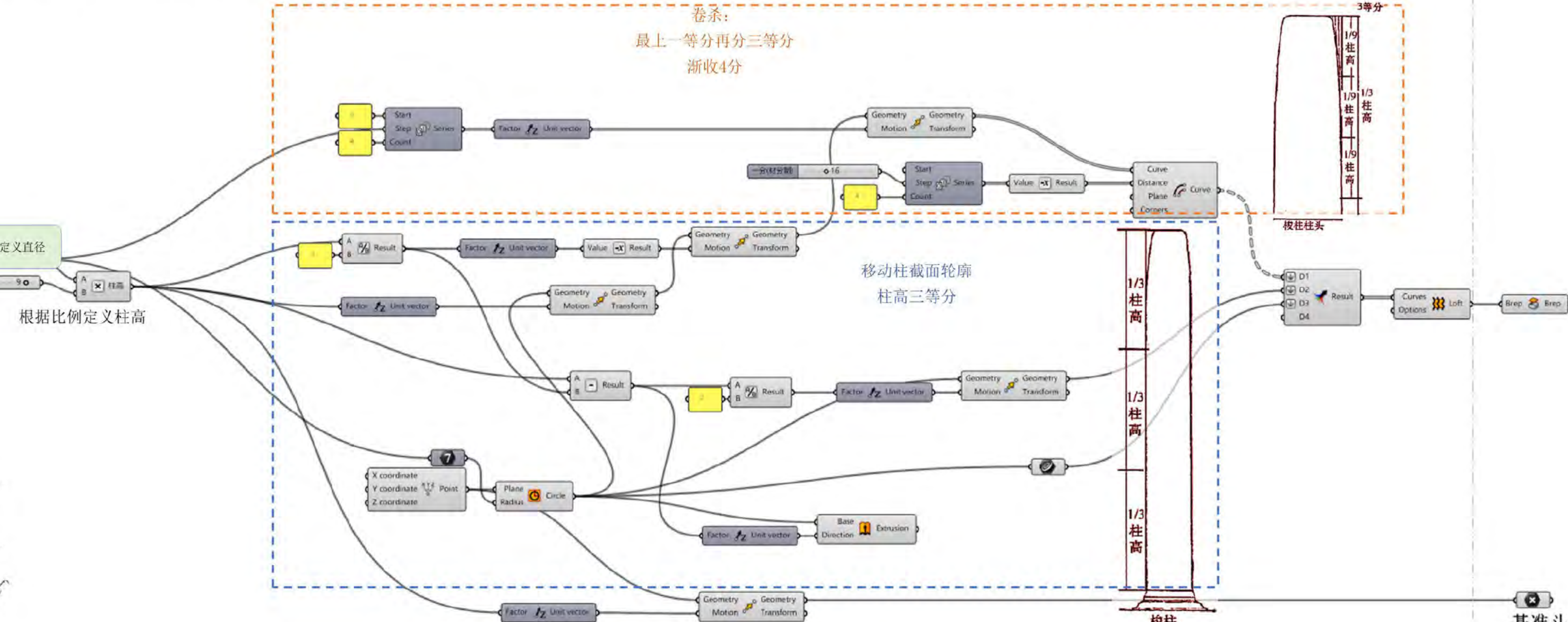
- Aim:** To introduce parametric modelling in the 3D reconstruction processing and enrich the semantic information of Chinese H-BIM.
- Objectives:** To enrich the parametric library based on ancient design principles, including typical components of Chinese built heritages;

## Preliminary Results



MAV was used to obtain image data of the entire architecture, and a ground laser scanner was used to obtain the point cloud data of the first layer. The actual scale of the architecture can be measured according to the collected data, and combined with the historical surveying document, using the construction ruler of the Song Dynasty (宋营造尺) as the basic scale, the structural principles of the pagodas were determined.

The first layer of the east pagoda was selected for parametric modelling. Grasshopper, a plug-in of Rhinoceros software was used for generating the parametric elements. According to the historical design principles, the basic parameters *Cai* and *Fen* can be defined in Grasshopper, and then other following parameters can be derived. These parameters were used to generate the component models based on the design principles of "*Yingzao Fashi*". Finally, according to the positional relationship between each component, the components were spliced to generate a complete model of the architecture.



## Future Works

- Investigation on suitable algorithms to improve the identification process, then map the parametric elements onto the point cloud;
- Combination of multiple data acquisition sources to better identify various kinds of defects;

## References

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