Applying BIM to Parametric Automation Modeling- A Case Study of Dou Gong

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ABSTRACT

Building Information Modeling (BIM) is a substantial system to increase intelligent construction which bring about parametric design popularity, it not only increases integration of building information, but also benefits in designing process. However, in Yinzou Fashi, it standardizes the size, scale, combination of components and layouts, which implies parametric processes. Therefore, this study aims to apply parametric modeling to Yinzou Fashi to seek the possibilities in parametric design. The process of this research firstly, to review the connotation of parametric design, secondly, to study and analyze the components of Yinzou Fashi Dou Gong, thirdly, taking parametric to modeling. Finally, evaluate the performance of the model. It is not only constructed refined parametric model, but also created a Dou Gong parametric design platform for further usage. For instance, applying for future designs, educations, references, for further research and so on, it can also be analyzed by other programs such as structural analysis and construction simulation.

INTRODUCTION

Smart object has a close relationship with BIM, aside from the traditional BIM system, objects cannot correspond to reality, and the precise scale, form and texture can’t be determined by the end of the designing process, however the smart object can decide most of decision in the early stage of the process. BIM and Smart Object
both have common data such as wall width, wall height, textures, but the difference between these two is the Smart Object is more interactive with the user, and emphasize position, function, additional features, relationships with other objects, the application of a Smart Object can drastically increase the efficiency of the designing process, the object can be adjusted immediately when the problem is occurred[1]. In the aspect of computing science, objects contain Attribute, Function with in the virtual world, and within the object there is Class, such as doors, windows and walls[2], but the smart object emphasize knowledge, and the use of parameters is the key to import knowledge into the object, parametric contains all of the data, including scale, texture, forms[3]. Applying parametric design to Smart object can efficiently control design process, and makes the object more adaptive to the model, the object can be changed instantly while the model has been modified, smart object Smart objects can be changed by the rules set by the programmer, for instant, in order to follow the rules of the construction regulations of the building core, the smart object can adapt into the model to fit into the building core[4]. In Yinzou Fashi, it standardizes the size, scale, combination of components and layouts, which implies parametric processes. Therefore, this study aims to apply parametric modeling to Yinzou Fashi to seek the possibilities in parametric design.

YINZAO FASHI AND PARAMETRIC DESIGN

Yinzao Fashi is the first book that illustrates official works of architectural and engineering, the book regulates various architectural practices[5], it provides a variety of construction design, materials, structure, proportion and other requirements, and determine the proportions, positions, and relationships between the various components, it is equivalent to today’s construction design, materials, construction and other aspects of the rules, in other words parametric design and Yinzao Fashi is rule-based[6]. Parametric design is performance-oriented design process, it is a series of parameters and relations between parameters, according to the performance of the building, such as, given scale, texture, form and so on, the design can be done, therefore, no matter how you design, as long as the parameter is enough the design can be done[7]. There are also several parameters regulated in Yinzao Fashi, the proportion and size of the wood are based on Cai as a basic modulus, the plan of the building are also regulated by proportion, and the number of Kaijian also determines the type of a building[8]. The methodology includes unit component, composite component and construction sequence parsing.
UNIT COMPONENT

Figure 1. General Coordinate geometry definition of Gong element.

Unit component includes spatial data and attribute data, spatial data also includes object geometry data and topology data, the attribute data also includes name, material, and parameter. The mathematical relationship can be described below: Object=(kind, spatial data(sd), attribute data(ad))(1), Spatial data=(geometry(gy), topology(ty))(2), Attribute data=(name, material, parameter)(3). The following will use Hwa Gong(HC) as example: Object HC=(Gong, HCsd, HCad)(4), HCsd=(HCgy, HCty)(5), HCgy=(c Geometry[HC parameter])(6), HCty=(c Topology)(7), HCad= (“Hwa Gong Double Juan Tou”, “Wood”, “HCparameter”)(8), HCparameter= (Length, Height, Thickness, gs_n, gs_d)(9). From the geometric point of view: Geometry[HC parameter]= (left, middle, right)(10), Geometry[ ] is geometric coordinate transformation, HC parameter is the parameter wish to be converted. (The center of the Gong is defined (Fig.1) as x=0, A=mid_seat/2, B'=A+3, B=A+1, C=B+eye_r, D=E-eye_r, E=F-side_seat, E'=E-2, F=length/2, G'=mid_dn_w/2, d_n=5, d_a=0, b=d-up_gs, c=d-eye_r, d=height, d'=d+4,d"=d+height2.), left=((A,d')(B',d')(B,d)(C,c)(D,c)(E,d)(F,d)(GS[HC parameter])(G',a)(G',dn)(A,dn))(11), left_eye=((B',d')(B',d')(B,d)(C,c)(D,c)(E,d)(E',d')(E',d')(E',d')\(12), right=-(left)(13), right_eye=(left_eye)(14),middle=((A,du)(A,dn)(A,du)(A,dn))(15), GS[HCparameter]=GS(gs_n, gs_d]=(F,b) (1,i) (2,ii) (3,iii) ••• (n,m) (G,a)(16)[9].

COMPOSITE COMPONENT

The type of Dou Gong is determined by the types of Puzhuo, and the Puzhuo is determined by the types of building, such as six Puzhuo Chong Gong which is used in temples. The composite component is a number of components combined into a composite component, or groups of components combined into a sector component, And each combination of components have their corresponding combination of component relevance, such as six Puzhuo Chong Gong single jump double Xiaang, turn inside five Puzhuo Chong Gong double jump central cross, the component correlation matrix analysis of its combination is shown in (Fig. 2), it is easy to mark
component combination in forms in the position of the coordinates, the X axis represents (Fig. 2a) Litiao and Waitiao which means number of Dou and Gong is extended, the Y axis represents (Fig. 2b) number of Dou and Gong is extended upward. By using this chart, the relationship of each component can be analyzed clearly. The (Fig. 2) shown below is an example of six Puzhuo Chong Gong, Nidao Gong and Hwa Gong is intersected, so at the position of n=1 Hwa Gong is extended to -1 and +1, at n=2 Gwazi Gong and Hwa Gong is intersected, and Hwa Gong is at the position of -2, Hwatouzi is at +1, Shuatou and Ling Gong is intersected at n=4, and the position is at +3[9].

![Figure 2. Composite component analysis of six Puzhuo (left to right: (a) side view, (b) front view.](image)

**SEQUENCE**

Sequence is how the composite component is assembled from a unit component or a combination of components, and the relationship with the element above and below, take (Fig. 2) for instance, CompositeComponent=“six Puzhuo Chong Gong”, Sequence=“Lu Dou+Hwa Gong Double Toujuan*Nidao Gong+Hwa Gong Single Toujuan, Hwatouzi, Xiaang1*Gwazi Gong, Man Gong, Gwazi Gong+Shuatou, Xiaang1, Xiaang2*Ling Gong, Man Gong, Zhutou Fang, Man Gong, Gwazi Gong+Xiaang1, Xiaang2, Shuatou*, Pingmu Fang, Luohan Fang, Zhutou Fang, Luohan Fang, Man Gong, Ling Gong+Tiaogan, Cheng Fang Tou*Yiachao Fang, Pingmu Fang, Liaozan Fang+*Ling Gong4,*Timu*Zhu”, “+” represents the assembly layer, “*” represents intersected elements. The definition can be organized like sequence = (BA (BC (LR (LD (HC *NDC (JHDQXDJDHD (HC&HT *GCC *MC *GCC (JHDQXDQXD JHD SD (STu XA1 *LC *MC *ZTF *MC *GCC (JHDQXDQXD JHD SD (XAXD STd *PMF *LHF *ZTF *LHF *MC *LC (JHD SD (CFT *YCF *LHF *LZF (QXD (*LC (QXD (*TM (*TIM[max)))))))))))))))))))).

*represents vertical combination, every brackets inward represents it is connected above each other. Definition: pillars (BA), column (BC), Lan Er(LR), Lu Dou (LD), San Dou(SD), Jiaohu Dou(JHD), Qixin Dou(QXD), Hwa Gong (HC), Hwa Gong and Hwatouzi (HC&HT), Xiaang I (XAI), Xiaang II (XA2), Shuatou I (STu), Shuatou II(STd), Cheng Fan Tou(CFT), Nidao Gong(NDC), Gwazi Gong (GCC), Man Gong (MC), Ling Gong(LC), Timu (TM), Zhutou Fang(ZTF), Pinmu
RESULT

The result of this paper is using ArchiCAD GDL to coding an automotive model to create a smart Dou Gong object, by controlling the 3D geometric coordination and the relationship between elements, these elements includes Nidao Gong, Gwazi Gong, Man Gong, Ling Gong, Hwa Gong different object definition, and each elements can be controlled with parameters and the combined elements can also be controlled by users, the type of the Dou Gong is determined by the number of Kai-jian, so the smart Dou Gong object can also adapt it, which means it can change freely while the number of Kai-jian is changed. The simulation result (Fig. 3) display a good performance, but still has further research value.

![Figure 3. Simulation result.](image)

REFERENCES


