Research on Algorithms in Platform Parametric Design Based on GC Building Design

Jupu Yuan\textsuperscript{1,*}, Feng Ye\textsuperscript{2}
\textsuperscript{1}Wuchang Institute of Technology, Wuhan, Hubei, 430000, China
\textsuperscript{2}CITIC Architecture Design Research Institute Co, Wuhan, Hubei, 430000, China

*Corresponding author e-mail: yuanjupu5690@wut.edu.cn

Abstract. Nowadays, digital technology has been applied in various fields. As far as the architectural design industry is concerned, computer-aided design and artificial intelligence simulation design have greatly improved the design technology of the architectural industry. This paper mainly elaborates the new possibilities brought by the parameterized software GC to the construction industry.

Keywords: GC, Ancient Buildings, Parametric Design

1. Introduction

GC provides a new architectural design idea, it combines the perceptual knowledge of the real world with the innovative consciousness of transforming the world, and it uses innovative materials and components to transform inspiration and creativity into realizable architectural works. Once the relationship between the underlying logic and the design is determined, the designer can create a new model, they don't need to manually construct (or rebuild) detailed design models for each plan [1].

2. Introduction to GC

GC is a design tool that opens a new era of architectural design. GC adopts a parametric modeling method, using human thinking logic, and only by setting the relationship between elements, various spatial shapes can be formed. When your idea changes, you can easily change the entire model just by modifying the logic. It is not like other software, such as CAD, which completes the design concept by drawing lines one by one, and stays at the stage when the software is only used as a tool for humans. The principles of GC include the following aspects.

(1) GC is a brand-new parameterized and correlated design software, which provides users with a new and efficient way to consider different designs [2].

(2) GC uses parameterized and scripted methods to describe the basic design components and the logical relationships and derivation rules between the design components.

(3) Through the GC, the basic design components can be changed, and the parameters describing the change rules and derivative relationships between the components can be changed, thereby quickly generating different alternatives and optimizing the design.
(4) In GC, the combination of parameters can be optimized by way of program, so as to further optimize the design. GC is the best choice for designers who think that the design process is a combination of intuition and logic.

3. Use parametric design of different roof models

Using GC's parametric design ideas, the real perceptual materials are digitally expressed to generate parametric objects in GC, and the new features of GC are used to realize roof models of different structures. First use GC to create a simple curved roof. It can be used in the design of various curved surfaces, such as bridges. Based on it, complex curved roofs can be designed [3].

3.1. General curved roof design

In order to create a curved roof with adjustable parameters, first create two base points, point01 as the control point and point02 as the base point of the roof, and design based on these two points.

(1) First create points point01 and point02, and generate line01 by the line.ByPoints method.

(2) With point02 as the starting point, line02 is generated by the line's line By Start Point Direction Length method. Generate the roof surface from the end point of line02 (line02.EndPoint). The parameter "Direction" is baseCS.Zdirection, and the parameter "Length" is set to 5.0/(Line01.Length+1.0), so that when point01 is moved closer to point02, the length of line02 will increase as the length of line01 decreases. Setting "+1.0" is for when point02 coincides with point02, that is, when the length of line01.Length is zero, the length of line02 remains unchanged.

(3) Use the series function to change point02 into a dot matrix, then line02 also becomes a series line, and line02.EndPoint also becomes a dot matrix, which can be used to generate roof surfaces. Set the Visible property of point02 to "false" (4) Using line02.EndPoint as the base point, the roof surface is generated by the BSplineSurface.ByPoles method of the surface. When point01 is moved, line02.EndPoint will change accordingly to generate different curved roofs [4].

One of the parametric roof models generated in the GC is shown in Figure 1. In GC, every step of creating a model is recorded, and a certain step can be deleted or returned to a certain step for modification at any time; at the same time, the created point, line, body and other objects are generated according to the parameter relationship between them. The relationship diagram allows people to clearly see the relationship between various geometric forms and between various components, which facilitates the correct creation of models.

Figure 1. Simple curved roof
3.2. Parameterized design of grid roof
In GC, you can define a new feature yourself and cover this feature on the surface of other models. We use this method to realize the parametric design of a grid roof. The creation of a grid roof makes it possible to realize a more complex curved space structure. The parametric design method of the grid roof is as follows [5].
(1) Create the curved surface path of the roof: place four circling points in the geometric modeling environment of GC, and create the curved surface path of the roof by the curve BsplineCurve.ByPoles method;
(2) Create the "T" section of the roof
1. Use the Plane.ByParameterAlongCurve method of the plane to create a plane plane01 perpendicular to the surface path. The initial value of the parameter "T" is any real number between 0-1. When different values are taken, a plane is created at the corresponding position of the surface path. Select the "free" option, the plane can move along the curved surface. Then create a plane plane02 perpendicular to the plane plane01 by the plane's Plane.ParalleToPlanThroughPoint method.
2. Add the roof height line01: take plane01 as the starting point, plane02 as the direction, and "5-plane01.Z" as the length to generate the roof height. The height of the roof will change as the path of the curved surface changes [6].
3. Create a section of the roof: create direction01 by the DirectionByPlanePlaneIntersection method of the direction, select "plane01" and "plane02" as the parameters; create a straight line line02 with the parameters "plane01", "direction01" and "line01.Length*0.5" by the LineByStartPointDirectionLength method of the line; Create a straight line line03 with the parameters "plane01", "direction01", "line01.Length*(-0.5)". The "T" section of the roof is formed by line02 and line03 plus the roof height line01.
4. Copy of the section (extend along the curved surface path): Change the value of the "T" parameter of plane01 to "(0,0.2,0.4,0.6,0.8,1.0)" or "Series(0,1.0,0.2)" , Which realizes the replication of the cross section.
5. Create the roof surface Create BSplineSurface01 with the BSplineSurfaceByPoints method of the surface, and fill in "(line02.EndPoint,line01.EndPoint,line03.EndPoint)" in the parameter Points to construct the surface model of the roof.
6. Create a user-defined feature "crossbar polygon" and use it to fill the roof surface
7. Generate grid points and diagonal grid polygons on the roof surface; First place a point point05 anywhere on the roof surface, set the parameters U and V to "Series(0.01.0.0.05)" and "Series(0.01.0.0.05)" , and use the "replication" method to get the grid points covering the roof surface. Then use the PolygonByPointGrid method of polygon to generate the diagonal grid polygon polygon01 of the roof.
8. Create a "polygon" object; Create a diagonal polygon polygon02 outside of the roof model.
9. Create a user-defined feature "crossbar" Select the "New Feature" tool of GC, take polygon 02 as input, set "name" to "crossbar", and set other options to complete the creation of new features [7].
10. Fill the roof surface with new features Using the crossbarByDefault method of the new feature crossbar, select the roof surface polygon polygon0 as the input, that is, the cross polygon filling of the roof surface is completed, and the grid roof design is realized. By adjusting the four basic points of the curved surface path to different positions and changing the values of the parameters U and V of point05, different roof models can be realized. Figure 2 shows one of the grid roof models generated in the GC.
3. Modify the value of the parameter V of point05 to: \( V=\text{Series}(0.2,0.8,0.1) \), which realizes that the mesh model is generated only on part of the surface of the roof, as shown in Figure 3.

3.3. Parametric design of polygonal roof of book pages

Inspired by the common open book pages in reality, using this as a prototype, parametric description can simulate the window design of buildings.

Define the user-defined feature as a "fold-polygon" similar to an unfolded book page, fill the roof surface with it, and you will get a book page style roof. This type of roof can be used for the design of exhaust walls after expansion and transformation. It can also be applied to the design of building windows after considering the sunlight angle and time factors. The realization method of book page polygon object in GC is as follows [8].

First, create a polygon polygon02 consisting of four points. Raise any vertex of the polygon for a certain distance to a new point, connect this point and the other three vertices of the polygon to form a new polygon polygon03, which is a new feature component "fold-polygon". This distance is represented by the parameter "opening", so that a page polygon with different opening and closing degrees can be realized. One of the book page polygons implemented in GC is shown in Figure 4 [9].
The polygon vertex polygon02.Vertices is represented by a parameter variable "vertex", which can easily realize the elevation of different vertices, corresponding to the generation of book page polygons with different angles. Change the value of the parameter "vertex, and the achieved page polygons with different angles are shown in Figure 5 [10].

4. Conclusion
In summary, for a specific design case, the model is not determined all at once, nor is it to design an exaggerated form of expression. We have to try to find the most effective structure for the solution. Therefore, this requires the collaborative work of architects, structural engineers, building physics engineers, mathematicians, computer programmers and other personnel.

Acknowledgments
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