Research on parameter application of complex structure surface in 3D modeling of product design

Wenming Liu[1a], *Zhenyu Wang[2b]
[a]liuwenming@sjzu.edu.cn

[b]*296341154@qq.com

[1]Shenyang Jianzhu University, School of Design and art, Shenyang, China
[2]Shenyang Jianzhu University, School of Design and art, Shenyang, China

Abstract. By using parametric design to design and apply complex surfaces, the modeling efficiency of complex surfaces can be improved, and the parameters can be adjusted in real time to adjust the model to reduce the deviation of some parameters in the traditional modeling method. Overall adjustment flaws. Simplify the modeling of complex structures and surfaces through parametric design, provide reference ideas for the rapid modeling and adjustment of complex surfaces, and promote the design and application of complex surface products in industrial design.

Keywords: Grasshopper; Parametric design; Complex structure surface

1 Introduction

With the development of computer technology, in industrial product design, the influencing factors of product shape design are often determined by product shape design, material color design, and use function design. On the premise of ensuring its functional use, the modeling design has become the influencing factor of the product characteristics. In the traditional modeling design, the traditional modeling production is often dominated by mechanical compaction molding and gypsum mold grouting molding. Usually exhibits a mechanical, poised, geometric, and concise character, but lacks individuality and interest. In order to meet the individual needs of consumers, industrial products with complex surface structures can better meet the individual needs in terms of modeling. Compared with the traditional design ideas of geometrical modeling, complex surface structures have a greater impact in the design stage. difficulty. This is because in the design stage, the designer needs to repeatedly modify and analyze the product model according to the changes of the geometry and surface, and spend a lot of time and energy on screening. In the face of random distribution and complex structures, the design is difficult and the design cycle is long.. Parametric design is to constrain the model through several parameters to obtain design results that meet the requirements. In the design of the surface, the modification of the scheme is extremely difficult to modify in the traditional design process. The change of the parameters of a certain structural part may require the adjustment of the model as a whole, while the parametric design realizes the design by establishing a logical relationship and formulating algorithm rules. Finding the modeling structure in the dynamic helps the designer to open up new design ideas in the process of designing the surface modeling of the complex structure.

ADDT 2022, September 16-18, Nanjing, People's Republic of China

DOI 10.4108/eai.16-9-2022.2324913

2 Status Quo of 3D Modeling Technology for Product Design Type Style and Fonts

Product design 3D modeling technology, the model can be designed quickly and conveniently through different software. The most commonly used software are AutoCAD, 3DMAX, rhino and so on. Because AutoCAD is digital drawing, it is quite accurate in drawing precision, but the modification of curves is not as good as 3DMAX and rhino. In 3D modeling, the curve changes greatly and the structure is relatively complex, especially in the complex structure surface. 3DMAX is often used for interior decoration scene design, Rhino is more outstanding for accurate design and complex structural surface design. When designing with Rhino, the model is first analyzed, and lines are drawn on the basis of the analysis. Each line affects the establishment of the model. On the basis of the line drawn, the surface and volume are established, and finally combined into the main body of the product. After the overall model is established, the rhino file can be imported into the keyshot software for model rendering, which has the advantages of fast drawing speed and high image quality. In addition, Rhino can also be associated with subsequent manufacturing links. Output format files, import format files into 3D printers, generate processing codes, and quickly print virtual models. Therefore, 3D modeling technology is favored by designers. However, in the design of complex structural surfaces, the amount of calculation in the model analysis process is too large, and it is difficult to calculate in the face of random distribution. In this case, the Grasshopper plug-in can be used to carry out parametric design of the model. [1]

3 Parametric design elements and related theories

Parametric design (parametric design) is a processing method based on algorithmic thinking mode, which can effectively organize all aspects of conditional factors, and achieve visual design intent by defining rules, combining arrangements and coding [2] . Parametric design takes the Rhino visualization plug-in Grasshopper as an example. Grasshopper has two characteristics, one is a programming calculator, and the other is a geometric calculator. Logical operators can be turned on using set and meth during parametric modeling , while geometric operators are distributed among surface, vector, mesh, curve, transform, and intersect. [3] The geometric operator needs to carry out the calculation constraints through the logic calculator, and the function of the logic operator needs to be expressed by the geometric operator. The parametric design is different from the traditional design method, which is modeled by the change of the surface. Instead, the parameters are set by programming and the overall model is constrained according to logical rules. Through the visualization of the programming process, after the program editing is completed, if the designer wants to The relevant part of the model is adjusted regionally, and the corresponding part of the programming flow chart can be adjusted, so that after the adjustment of the regional part, the model as a whole will not be wrong due to the partial adjustment. Grasshopper has powerful parameter processing features, and Grasshopper uses computer language data processing and display methods . The data processing display is a tree-like program diagram, which is divided into single tree-like data and multi-trunk tree-like data. The tree-like data output is linear data, which should follow the linear data processing rules, otherwise the display bar will be red to indicate a running error. That is, different pairing methods are pre-

sented in different modes of shortest list, longest list and cross reference. The output of Grasshopper is complex and adjustable. [4] First, the Grasshopper program can process multiple sets of data at the same time, the calculation speed is much higher than that of the human brain, and the presentation method is much better than manual work, so it can generate complex shapes that are different from traditional ones. Secondly, the characteristics of the data program bring great adjustability to the output results. After the program rules are completed, the designer can modify different parameter values to obtain a series of different complex structural surfaces. Massive complex structural surfaces are easy to design. The designer explores new modeling structures and new design inspirations, breaking the traditional geometric and regular modeling formulas. Thereby, the speed of model generation and modification is improved, the work efficiency is improved, the design labor is liberated, and the designer is urged to go deep into the more complex design field. The parametric design is different from the traditional design method, which is modeled by the change of the surface. Instead, the parameters are set by programming and the overall model is constrained according to logical rules. Through the visualization of the programming process, after the program editing is completed, if the designer wants to the relevant part of the model is adjusted regionally, and the corresponding part of the programming flow chart can be adjusted. After the regional adjustment is achieved, the whole model will not be adjusted due to partial adjustment, but the model will have errors.

4 Parametric Design and Analysis of Complex Structural Surfaces

In the process of parametric design of complex structural surfaces, designers need to first conceptualize, determine the overall shape and surface shape of the expression, analyze the geometric characteristics of the design target, use parametric methods to abstract the concept, and formulate complex structural surfaces to achieve By modifying the rules and algorithms or parameters, the designer can realize the change of the shape of the complex structure surface, and obtain it from a large number of complex structure surfaces that meet the requirements and have different shapes due to different parameters. optimal form. The design process is shown in Figure 1.

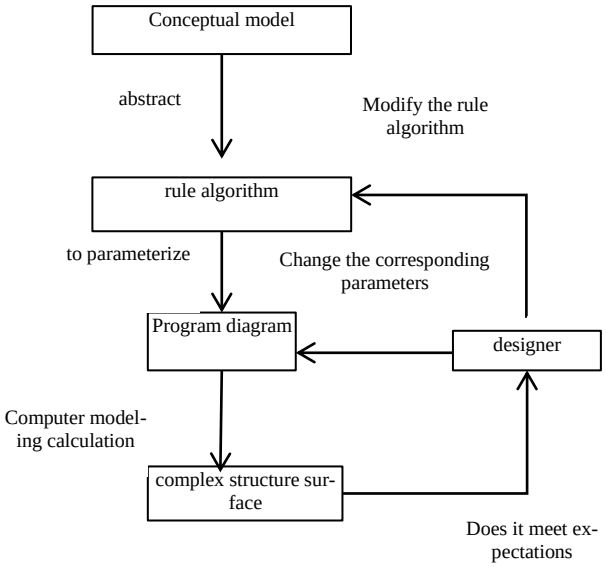

Fig. 1. Grasshopper design flow chart

In the traditional Rhino design software, the surface design needs to be designed from the bottom up according to point-line-surface-body, and every adjustment of point, line and surface needs to be modified from the bottom layer. [5] In the optimization stage of the product model, the adjustment of the shape is an essential process, but the adjustment of a certain detail needs to be modified from the bottom. This process covers a lot of repetitive work and command execution time, reducing It improves the design efficiency and design accuracy of the designer. The parametric design of the model is carried out through Grasshopper. After the target model is compiled according to the parametric program, the model can be changed linearly according to a certain trend only by changing the logic algorithm or related parameters. Adjust the observation of model dynamics to find the best complex structural surface model. Therefore, parametric design makes the design of complex surface structures simpler and faster, and it is more convenient to modify in the later stage, which is of great significance to the design of complex surface structures of products.[6]

5 An example of parametric design of complex structural surfaces based on Grassshoper

In order to demonstrate Grasshopper's parametric design of complex structure surfaces, closed-loop complex structure surfaces are selected for modeling design. The position of the outer contour is changed to generate a new shape. Due to the complexity of the surface, the modeling is more difficult. In terms of modeling, because of the existence of limited points, the modeling is too simple and lacks innovation. Based on the above two points, the parametric design of the

closed-loop complex structure surface is carried out by using the advantages of parametric design, and a series of closed-loop complex structure surfaces that change linearly are output through a dynamic design method.[7]

5.1 Construction of closed-loop complex structure and surface morphology

First, create a circle with the origin as the center on the Rhino interface, divide the curve into equal lengths through divide curve logic, then create a plane according to the x and y coordinate axes through Construct Plane logic, and use Rotate logic to rotate the line perpendicular to the circle. Then through the logic of Lift Length, Pi, Range, Cull Index, etc., a line segment that scatters out regularly is created. Then, a higher-order surface is formed according to the scattering line segment through Loft logic. The specific process is shown in Figure 2, and the shape of the surface is constructed as shown in Figure 3.

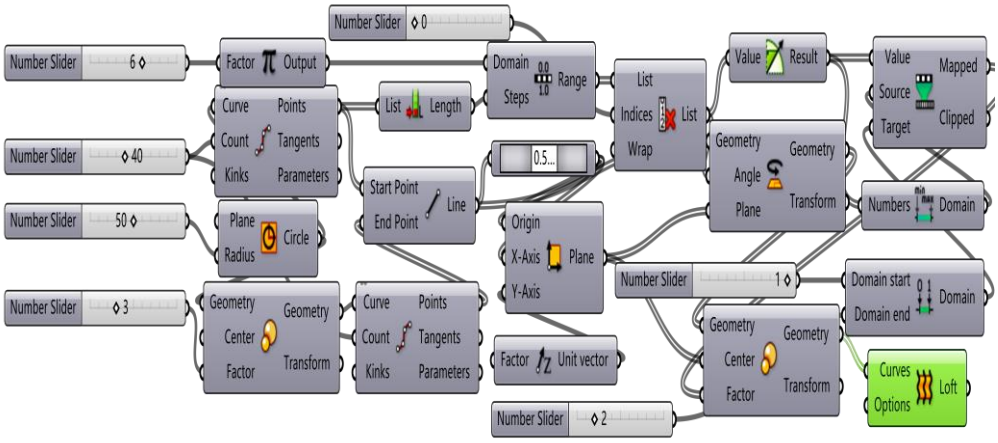

Fig. 2. Logic calculator to generate higher-order surface program diagrams

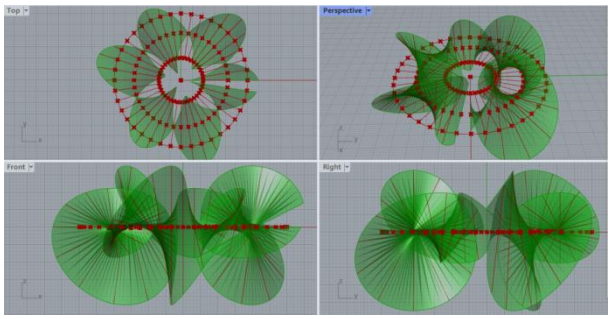

Fig. 3. Logic calculator to generate higher-order surface model diagrams

5.2 Model texture

The parameters output from the Loft logic are passed through the Brep logic and then the Offset Surface calculation is input to the Ruled Surface to create a surface between the curves, and then the result is input into the Merge logic, the final model is input into Geomtry to form a set,

and then the Colour Swatch logic is established Assign Material in Geomtry, as shown in Figure 4. The final effect is shown in Figure 5.

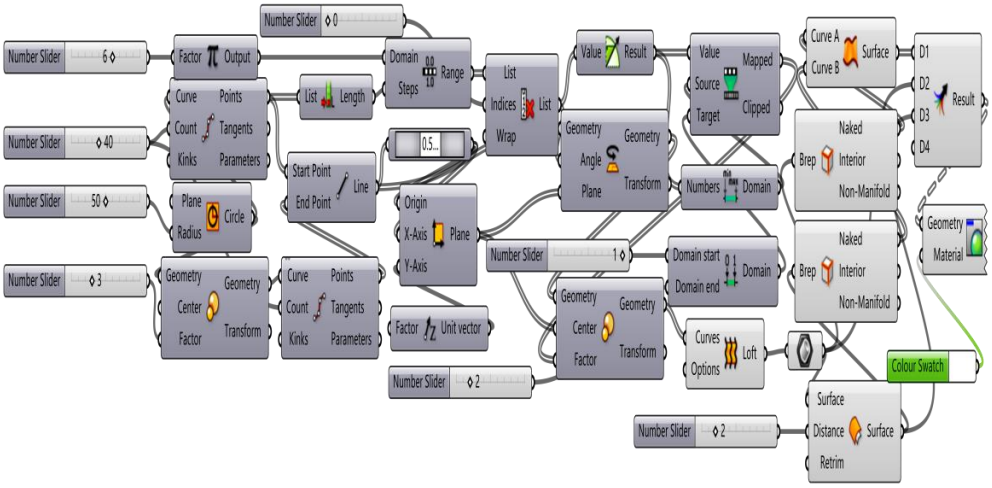

Fig. 4. Assign texture material program map

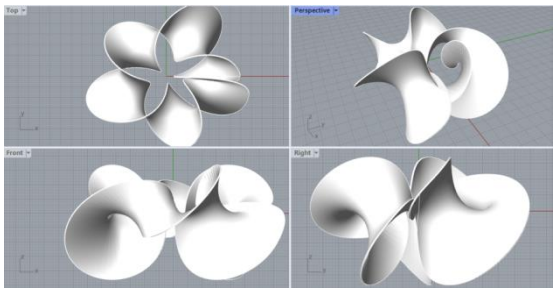

Fig. 5. Give texture material model map

5.3 Dynamic Morphological Construction

After the parametric programming is completed, the model can be optimized according to the design requirements. [8] For example, by adjusting the Number Slider, the parameters of the Pi logic input are changed, so that the overall model changes linearly, as shown in Figure 6. The model changes linearly by changing the Point on Curve parameters, as shown in Figure 7.

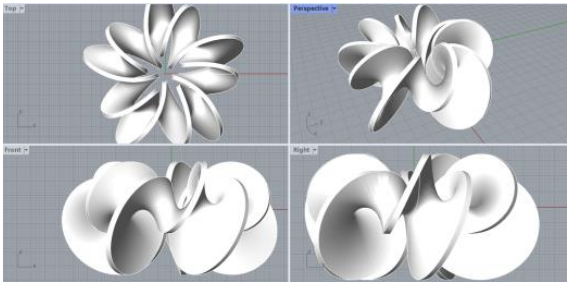

Fig. 6. Change the Pi parameter to optimize the model diagram

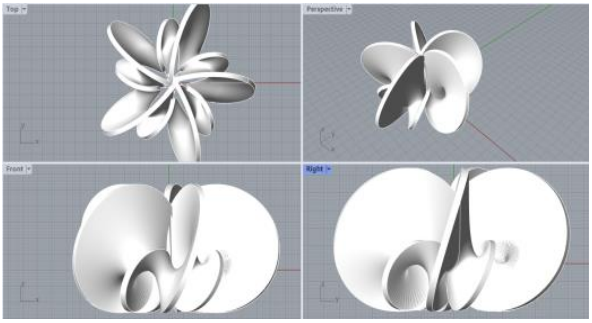

Fig. 7. Change the Point On Curve parameter to optimize the model diagram

6 Conclusion

Through Grasshopper parametric design, the design method of complex structure surface is optimized and improved, so that after the editing of complex structure surface program is completed through parameterization, the input parameters can be adjusted, so that the output complex structure surface model can be linear. Variations, presenting a dynamic design show finding the optimal model solution from a large number of linearly varying output models. The closed-loop complex structure surface is designed and studied by Grasshopper combined with Rhino, and different models based on linear changes are obtained by adjusting the parameters. It provides a new idea for the parametric dynamic design of complex structural surfaces based on Grasshopper. The parametric design is applied to the design process of complex structural surfaces, which effectively improves the design quality and design efficiency, and realizes the structure and modeling innovation of complex structural surfaces for the next step. Provide new ideas and play an active role in the high-quality development of complex curved surface product design and application in industrial design.

Acknowledgment

R.B.G Everybody.

References

[1] Liu WM, Wang ZY., 2021,In: Research on intelligent furniture design based on 5G interconnection technology [C] Second International Conference on Intelligent Design.
[2] Bai YS, Gao YH., (2018) Grasshopper Parametric Nonlinear Design [M]. Huazhong University of Science and Technology Press, Wuhan.
[3] Bian J, (2013) Parametric Discussion of Product Modeling Design [M], China Academy of Art.
[4] Zhang K, Zhang H. (2016) Application of parametric design in product form design [J]. Design.
[5] Zhang K, Zhang H. (2016) Application of parametric design in product form design [J]. Design.
[6] Dai, XW. (2016) Application and exploration of parametric design based on Grasshopper in product design [J]. Design, (6): 122—123.
[7] Dai CL. (2002) Research on Parametric Design Theory [D]. Nanjing University of Aeronautics and Astronautics, Nanjing.
[8] Zeng XD, Wang DC, Chen H.(2011)Rhinoceros Grasshopper Parametric Modeling [M].Huazhong University of Science and Technology Press, Wuhan.