

A Method for Modeling Conceptual Design with Irregular Surface

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Abstract

A new method of fast modeling conceptual model with irregular complicated surfaces is presented for fast and good design. Based on a Poly surface that is transferred from a NURBS surface, the 3-D model is established through a 2-D image corresponding to the conceptual complicated surface utilizing the Opacity and Displacement processes, also with the surface adjustment of SurfaceMapper(WSM)-3D Max commend. Experimental results show that this method of modeling can achieve the conceptual model with irregular complicated surfaces in a short time and with less data quantity.

Keywords: Computer Aided Conceptual Design, irregular surface; displacement map; opacity map; surface map adjustment

1. Introduction

Nowadays, with the endless pursue for the creation on the shape of new product, and the development of rapid prototyping technology, the shape of the current new product in the market has a great and revolutionary improvement from the regular surface in 20th century to the irregular and complex surface in this information era [1]. When the product development period has been shorten, Computer Aided Design (CAD), a new but widely used design method, stands for the one of most important tools in the product design process, and then becoming a necessary step of the product design procedure. CAD has numerous advantages, such as fast and accurate modeling, easy to use etc [2].

Although the current CAD technology is competence for the regular shape modeling, it is still time-consuming and data-occupying when come to the irregular surface modeling especially the complex irregular ones. There are two methods to deal with irregular surface modeling. One is Alias or Pro-E, as the top engineer modeling software, which is more accurate and well structured than other 3D modeling software like Zbrush and 3Dmax, but the limit will appear when it turns to the model whose surface is based on the mathematical formula or as complex as. The other is ANSYS [3] or SAP, it may solve the problem of complex surface based on the mathematical formula pretty well, but it must be base on a huge database for modeling [4], and it is impossible for a new conceptual design,

which needs fast modeling and rendering, preparing for the rapid prototype. As we know, in the current fashion product industry, how soon we can bring an idea into reality is the key to success [5], in other words, time is money. In order to fill the gap, author propose a new method to model the irregular surface in a fast way, for the conceptual designers. This new method integrates these two current methods mentioned above, solving this problem in a particular way and intelligent aspect. Experimental results show that this method of modeling can achieve the goal of modeling conceptual design with complex irregular surfaces in a short time and with much less data produced.

2. Process

A. Establishing Polygon Surface and NURBS Matching Surface

First of all, we established a new model in the 3D software. The NURBS function in 3Dmax is lack of stability and poor. So we chose the popular modeling software that good for the NURBS modeling-Rhinoceros. Rhino produces less data and operates fast. Designers are able to model the concept in a very flexible and easy way, the reason why Rhino leading the concept design market.

- Draw four ellipses with the same axis, and make sure they are all closed, as the guidelines of the main body. The Figure 1 shows the perspective view of these four curves in the Rhino viewport.

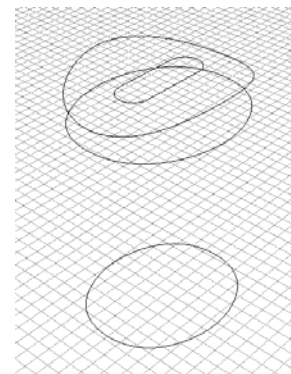


Figure 1. Four Ellipses for the Guidelines.

- Secondly, loft these four curves to form a surface, which is based on a humidifier project supported by Yadu Corporation. Figure 2 shows the position of the surface and from the appearance of the conceptual humidifier.

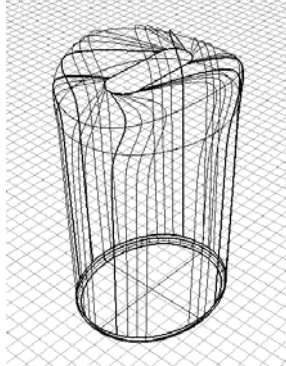


Figure 2. Surface from the Loft of Four Curves.

- Thirdly, we converted the NURBS surface into meshes. And we should choose 3DS format to encode the file, rather than IGES or DWG format. Because after that, we would have another NURBS surface for the adjustment, and the basic surface should not be in NURBS anymore, so that, it has to be saved in 3DS format or OBJ, or the other mesh format like that. To convert the NURBS into meshes or polygons, we are required to select the subdivision, in other word, how many polygons we want in the fix area on the NURBS surface. The higher subdivision we choose, the smoother the converted polygon surface is, and the larger amount of the data produced, and the more calculating time it will take. As far as this example concerned, due to the complexity of the shape and high resolution of the model we expect, we choose the highest subdivision for the conversion, as Figure 3 shows.

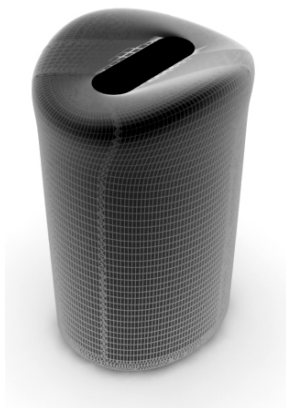


Figure 3. The Meshes of Highest Subdivision .

- Finally, we imported this model into 3Dmax for next steps. And for another preparation, we should establish another NURBS surface in 3Dmax, to adjust the polygon surface we just imported. This NURBS surface is the reference of the main model. It won't appear anymore in the final presentation, only guiding the maps adhere to the model in the way we want. So that it makes the mapping process exactly under our control, even any detail of that, which we will talk about in the next step. We can make this NURBS surface with the same method of the polygon surface we established in Rhino, but in a rough way. Since the NURBS function is poor in 3Dmax and this surface is only the guidance of mapping, we design it in sketchy form which is enough for the good effect. The pink one in the Figure 4 is the aligned surface.

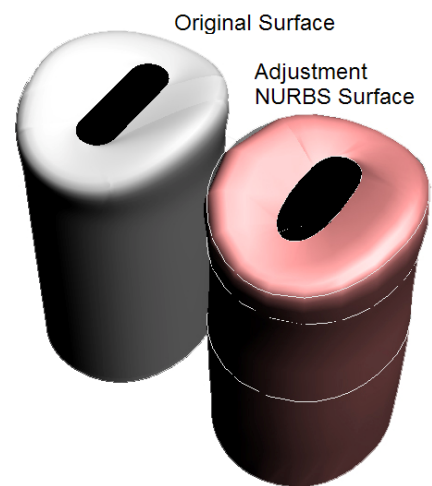


Figure 4. Surface from the Loft of Four Curves.

B. Surface Map Adjustment

The mapping adjustment process is the crucial step to convert 2D to 3D and form the real 3D irregular body in a quick way. The common mapping adjustment method is UVW Map. However, this kind of mapping just suits for the regular surface and entity such as cylinder, cube and sphere. In order to deal with the irregular surface mapping adjustment issue, we should use SurfaceMapper(WSM) to realize the refined mapping effect on the complex irregular surface. The step of this method is as followed. First, to establish a similar NURBS surface as the original surface, and this reference surface will be the guiding surface of the basic one, adjusting the mapping in a right way what we want. And this method makes the map on the irregular surface in hypodispersion. Second, put the map onto the original surface with the method of SurfaceMapper(WSM) and the NURBS surface as the reference. Figure 5 shows the comparison of the three methods-(1) without any adjustment, (2) with UVW Map adjustment, (3) with SurfaceMapper(WSM) adjustment. It's very obvious that the mapping which is with the SurfaceMapper(WSM) method is the closest to the effect we want.

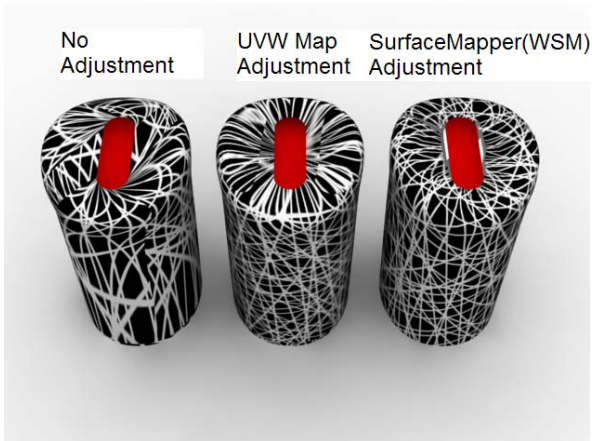


Figure 5. Comparison of Three Situations.

For the NURBS surface was established in a approximated way, the final effect might be a little unsatisfying from the critical aspect. So that, for the sake of solving this problem, we also can do the fine-adjustment on the mapping. In this case, we will use the unwrap mapping technology to realize the fine-adjustment on the SurfaceMapper(WSM). We selected the command of Unwrap UVW, and all the mapping is turned into flat and displayed one by one on the checkerboard as Figure 6 shows. After that, we can alter every control points on the flat mapping, observing the change has been made on the viewport simultaneously, to make the mapping in the way exactly what the designer want and express the design ideas in a more accurate result.

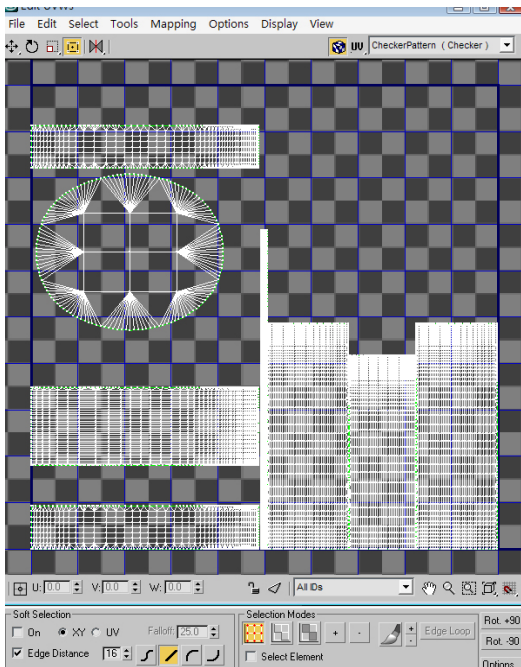


Figure 6. Unwrap UVW.

C. Adhesion of 2D Map with 3D Effects

In order to make 3D effect on the surface, to realize the complex shape based on irregular surface, we should adhere a 2D map on the basic surface and then turn it into 3D. First, before the adhesion, we made a 2D image as big as possible when we need the high resolution of the final presentation. Following the last example, from the design purpose that we want design a humidifier which having the same structure as Bird Nest Olympic stadium, we made a picture that contains the Bird Nest texture in Photoshop. Figure 7 shows part of the whole texture picture. In this adhesion process, we need two steps. First is to make the hole, and second is to make the thickness, in other word, to make the surface into entity. For the "hole", we use the Transparency option of Texture branch under the material sphere. In this texture, system only recognizes the texture image in black and white. And the part of black will be displayed in the final render, on the contrary, the part of white won't appear-they are transparent in the final render. For the thickness, we use the Displacement option of Texture branch under the material sphere. We also can use Bump option, but the difference between Displacement and Bump is that Displacement will make a real entity in the rendering calculating, oppositely, Bump will only add some shadow and other 3D effects to make it seems like an entity, but it won't create a real entity based on the texture as Displacement does, which will cost a lot of calculating time. Therefore, the effect of Displacement is totally real, a real entity has been created in the render process, but the Bump doesn't, so that the effect of which is not good as Displacement, and in our case, the difference is considerable. In order to turn the surface into entity, we should make another texture image; this picture is the invert of the transparent texture. Because in the Displacement texture system, which also accepting the black and white picture, the part of white will be thicken in the normal direction and the amount can be altered in the parameter box, on the contrary, the part of black is the null mark of this system, won't do anything to this part.

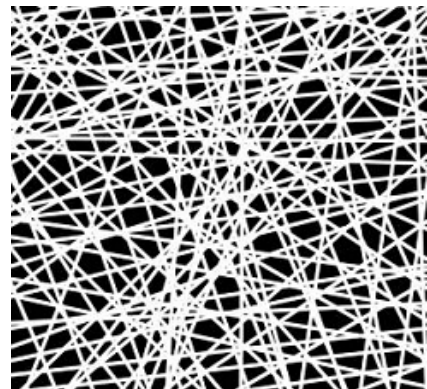


Figure 7. 2D Texture.

Finished these two texture pictures, we will edit the material. In this case, since we will use Vray Render plug-in later, so the Vray Material will be chosen for the material sphere. And also we can choose Standard Material, the advantage of which is that it allows Non-transparent texture, means that we can only have one texture picture to solve the

problem that the Transparent texture and Displacement texture are inverted. The benefit of doing this, is that we can use only one texture image which can be setup as Instance for later change of the size, position, tiling or rotation. It can save time of the adjustment for two different textures. The effect of the material sphere is as Figure 8 shows.

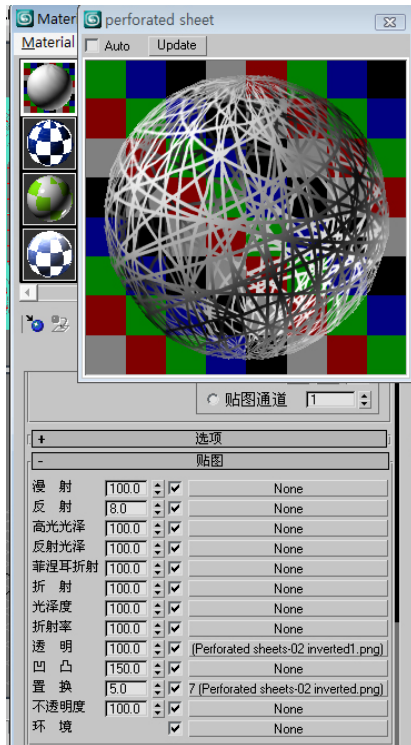


Figure 8. Transparent Texture and Displacement Texture.

The principal of displacement map is when rendering, the Poly surfaces of polygon will be automatically displaced based on the bumps and valleys of the maps. The difference between displacement map and bump map lies in whether or not the actual model will be changed. Bump mapping can just do some work based on the amount of counting light and shadows of the images, and the actual model will not be changed. But it will be changed as the displace map is used. As the maps are displaced on the surface, the bumps and valleys on the surface will be changed at the same time, and finally resulting in an actual 3-D model.

Based on the principal of displacement map, the subdivision numbers of a Poly surface is obviously very important, which will directly affect the precision and smooth level of the converted model. The subdivision number should be very high as the displacement map is used, especially when dealing with some complicated maps, for example, the bird nest humidifier.

The higher subdivision we choose, the larger amount of the data will be produced during each steps of editing the surface model, which will decrease the efficiency during the editing process.

In order to solve the problem, we need add an order called “Displacement Approx”, which is especially designed for the surface subdivision during displacement mapping

process. This order can pre-process the surface subdivision, which means the level of subdivision will only become higher when the displacement map is used during rendering and will not change at all during the editing process. Table 1 shows the detailed data of the surface subdivision. From this list, it is obvious for us to see that as the numbers of Edge, Distance and Angle decrease, the number of the faces increase, using more and more memory spaces at the same time. When the numbers of Edge, Distance and Angle reach 0.2,0.2,0.1, the amount of the faces become 7 times of the number of original faces, and the memory space increase 134.2M. And from this point, we can see, the method which can increase the subdivision level only during the rendering process will greatly lessen the data quantity produced during the editing process, resulting in higher working efficiency.

TABLE I. THE RESULT OF DISPLACEMENT APPROX.

E/D/A	Faces	Memory(Mbytes)
20 20 10	203716	483.4
10 10 4	641197	529.8
5 5 2	711570	543.4
2 2 1	951599	562.7
0.2 0.2 0.1	1246582	596.8
No Dis. Approx.	19900	462.6

E/D/A: Edge/Distance/Angle

Figure 9 shows the final model of the bird nest humidifier example after rendering, when the “Displacement Approx” order is added and the surface is displaced with opacity maps.

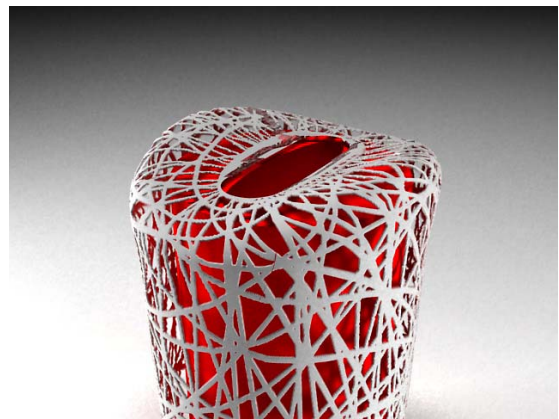


Figure 9. Final Presentation.

3. Future Study

This method for modeling conceptual design with irregular surface can be extended to more kinds of situation. In this design case, after designing a Bird nest humidifier, we will

design another humidifier, which is based on the Water cube. For the Water cube modeling, there is no need to use NURBS adjustment surface and SurfaceMapper(WSM), by reason of the surface of Water cube is regular, only the bump of the texture is really complex and hard to model. Hence, in this case, we only use the UVW map and choose the cube mode. But the main issue of this case is the gradient bump of the surface. Because the map of Displacement can be not only judged by black and white, but also any gradient grey in the middle. The amount of the displacement, how thick the shape will be, depends on the amount parameter we type in, and also depends on the degree of grey color of the mapping image. Based on this feature, we can make a more flexible effect of the conceptual design. Figure 10 shows the effect of the final render of Water cube humidifier and the texture image by its side. As we know, to design and establish a real model like that is really a hard work, no matter through NURBS or polygon modeling method.

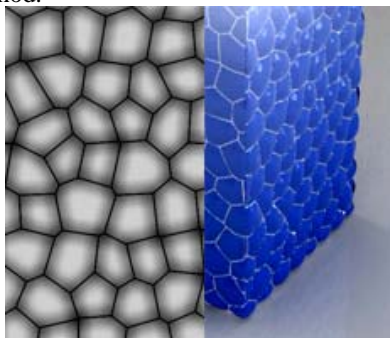


Figure 10. The Example of Water Cube.

Based on this integrated method, from the need of conceptual product design and presentation, the process of modeling can be alternative and extended to more fields of modeling issue. At present, this method can only be realized in multiple software. But 3Dmax indeed has the function of self-made plug-in based on the script, so that means we can design a plug-in for 3Dmax especially solve this problem in a quicker way, which will make conceptual modeling much easier. As we know, for designers, 2D design is much simpler than 3D design and less time-consuming. So this plug-in will help product designers realize their ideas very quickly and present it in a delicate effect, moreover, express the design idea not only in a exact but quick way. This kind of plug-in is based on the steps we talked above, and can be design in macros, so that will make it much easier.

4. Conclusion

In this paper, author stated the current methods of modeling and pointed out the advantage and disadvantage of each method. Following, the author pointed out the difficulty and urgent needs, which is existing in the conceptual product design field. After we analyzed the main function of current modeling software, we proposed a new method to realize fast modeling of conceptual design with irregular surface. This method utilizes the technology of 2D image texture, converting 2D to 3D, and at the same time, forms the real 3D shape body in the rendering process. There is no need to establish a real 3D model anymore, if it is complex and based on the irregular surface which is really hard to shape into model. This method can increase the possibility of realizing a complex conceptual design, improve the effect of the model's final presentation, efficiently decrease the data amount, largely shorten the time of modeling process of the conceptual product design. It provides a comparable mature method to get the idea come into reality in a very easy and quick way, especially for designers, who is not professional at modeling or calculating. It shorten the development time of the product, and gives great effect of the final presentation. Finally, in order to state the whole paper and the method in a convinced way, the author gives one example to indicate, and another example to illustrate the other uses of this method, proving that this method is comprehensive and can be widely used in many other fields.

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