GEOMETRIC COMPUTATION TO SURFACES DESIGN

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INTRODUCTION

As new explorer of building geometric modeling, this is an attempt to control the process chain that links a design idea to its digitalization to be produced. The goal is to get projects of high complexity to take flight thanks to mathematics, informatics and architecture since the link between these three worlds can enable so much more than the conventional architectural drawings. This method of modeling helps to find more freedom in designing, as well as more efficiency and safety in planning.

CONTROL OF THE DIGITALIZATION OF COMPLEX SURFACES

The obtaining of the final digitalization is the result of a chain of actions that have to be controlled from the first moment since one result will be consequence of the previous one. For a better understanding, I will briefly present the steps I followed in each of the phases in a determinated experiment. The main program used throughout all these experiments has been GhPython. It is the Python interpreter component for Grasshopper that allows to execute dynamic scripts.

Approach to the geometric problem: From the beginning we consider the geometric relationships that we want to maintain during the whole process and it is totally necessary to study in depth how they work.

Since I had studied about a mathematical concept called 'cross-ratio', the goal is to create a semi-discrete surface (discrete in one direction and smooth in the other) from a set of biarc curves in which all the vertices of every face are circular. After working on planar faces and consequently discrete surfaces, the choice of biarc curves is because of the structural advantages that we can obtain using circular arcs [1].

Applicability: The study of the maximum number of possibilities in which the procedure can be applied since the more possibilities you have to use it the more useful it will be.

In the presented case, the only restriction is that the initial curve has to be a biarc curve, This is not a problem because the file is ready so that there exists the possibility of transforming any planar or space curve into a biarc curve [2] just defining the number of segments.

Recognition of the parameters: The previous knowledge about the geometric relationships will help to recognize how flexible the results are. In other words, it will help to define the parameters which the initial element will depend on.

To get the successive biarc curves, we are going to use a similar process to the one used in [3] through spheres. The parameters will be the initial point of every biarc curve and the set of angle for every arc in every biarc curve. To work in a easier way the choice of the angle will be illustrated through a NURBS surface formed by NURBS curves that will be represented in a 2-D graphic.

From these transformations we realize that if we apply the null angle we will always get the symmetric biarc curve to which we are computing the transformation. Consequently, every two transformations with null angle we will get the original curve. We will call 'neutral' to this type of transformations.

In this case there exists a huge variety of possibilities. This is a nice aspect for design because there is no an only possibility.

Control of the final surface: It is the most important step for design since any designer wants the surfaces he is creating to go through a fixed or limited space. If the geometric procedures work in a chain, this control is harder since the change of a parameter in a part of the first curve will affect to the whole surface. In these cases this control has to be done step by step from the beginning.

One of the tests is to check the path of every curve with the control of the position of an endpoint of one arc every two arcs. This is possible with a list of desired points through which we want our curve to pass. To get it, we use the binary search algorithm applied to the values of the angles compared with the 'neutral' case.

Another faster test is established with the use of toggle component in Grasshopper. It is possible to approximate the shape of the surface to the desired one changing the values of the angles and fix them when the results are interesting so that new changes do not induce radical changes.

RESULTS AND DISCUSSION

It is almost impossible to get that the curve passes through the desired points as we presented in the first test because of the geometric limitations but from this method we may get good approximations.

Thanks to the use of toggle component in Grasshopper, there is a way to change the resulting surface in a smooth way and we do not have surprising and undesired results.

CONCLUSION

I have tried to show that there is a way to think of a geometric process to get surfaces and discover the way of controlling the possible parameters to get interesting results.

The next step is the improvement of these methods of controlling to get results closer to the desired ones.

REFERENCES

[1] Bo, P., Pottmann, H., Kilian, M., Wang, W., Wllner, J. 2011. Circular arc structures. ACM Transactions on Graphics (TOG), Volume 30 Issue 4.

[2] Parkinson, D. B., Moreton, D. N. 1991. Optimal biarc-curve fitting. Computer-Aided Design, Volume 23, Issue 6, JulyAugust 1991, Pages 411-419.

[3] Burstall, F., Hertrich-Jeromin, U., Lara Miró, M. 2017. Ribaucour coordinates. arXiv:1711.04605 [math.DG].