ALGORITHMIC ART-ARCHITECTURE 3D VORONOI/DELAUNAY AUTOMATIC GENERATED STRUCTURE

Ing. arch. Nina Hedwic
CTU in Prague, Faculty of architecture, Department of Building Construction I., Thákurova 7, 169 34 Prague 6, Czech Republic, ninahedwic@seznam.cz

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Summary

The 3D Voronoi/Delaunay automatic generated structure is one of the examples of algorithmic architecture. This branch of architecture - digital architecture is based on the designing smart scripts – computer programmes - which generate the most suitable solution for the particular task. Architect - the creator of the script – influence the final face and properties of the generated structure by entrance conditions at the start of the script computation. To find the connection between the not only aesthetic view of the computer generated structure at the end and the numbers and the letters of the computer script is the goal of my work.

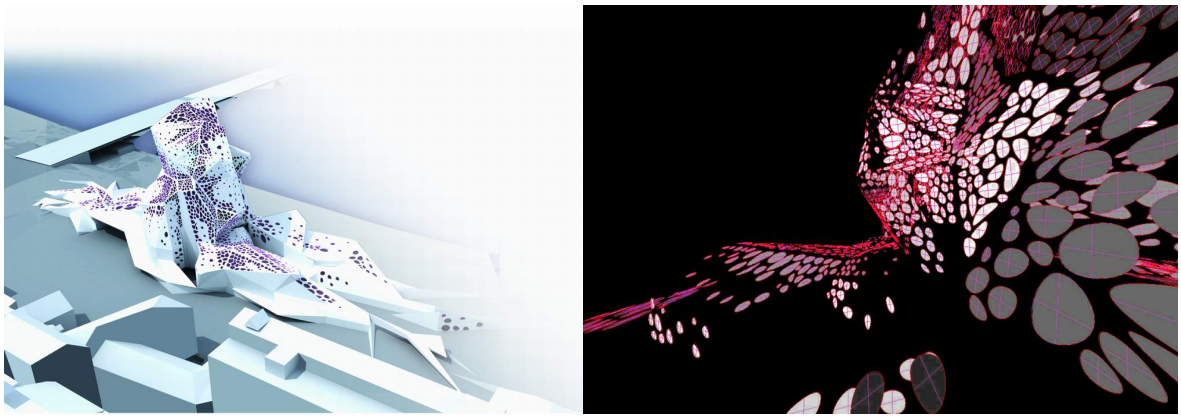

Fig. 1 Art Palace Prague. Diploma project, Nina Hedwic 2008. Parametric model of Voronoi and Delaunay diagram.

1 Introduction

My work started thanks to my diploma project in which I had to design in a quite short time three buildings – three art galleries. Every gallery should be in some way personally special and on the other hand in some inner way connected which the other two. So I tried to find some structure, which would help me to connect these buildings together and at the

same time keep they unique characters. Just this had inspired me to find some computer programme, which should be able to generate for every particular building site according to local conditions the suitable building. The solution is the programme, which works on the principle of Voronoi/Delaunay diagram structure.

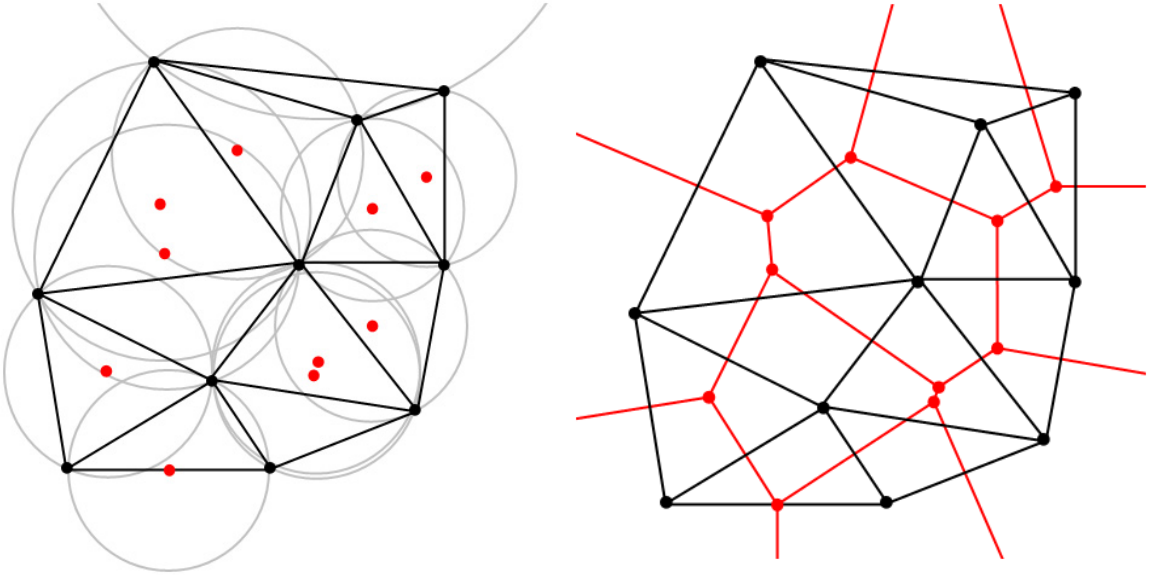

Fig. 2 Voronoi and Delaunay diagram.

2 Voronoi/Delaunay diagram

Voronoi diagram is the way of configuration of many structure in nature, for example the self-organising nature system like structures of bubbles in the lather. According to these structure decorate nature the skin of giraffes, many butterflies flies with this ornament…

In mathematics, and computational geometry, a Delaunay triangulation for a set P of points in the plane is a triangulation DT(P) such that no point in P is inside the circumcircle of any triangle in DT(P). Delaunay triangulations maximise the minimum angle of all the angles of the triangles in the triangulation; they tend to avoid skinny triangles. The triangulation was invented by Boris Delaunay in 1934 [1].

Based on Delaunay's definition[1], the circumcircle of a triangle formed by three points from the original point set is empty if it does not contain vertices other than the three that define it (other points are permitted only on the very perimeter, not inside).

The Delaunay condition states that a triangle net is a Delaunay triangulation if all the circumcircles of all the triangles in the net are empty. This is the original definition for two-dimensional spaces. It is possible to use it in three-dimensional spaces by using a circumscribed sphere in place of the circumcircle.

3 Working on the particular building site

On the particular building site works the computer script in this way. From the building site are used photos from the building site surroundings – orthogonal photos of the

neighbouring building facades. From these photos is made in 3D virtual model space a high map. It is made in this way. The bitmap photo is bent according to the size and direction of the normal vector with the number value of the colour contrast of the each bitmap point. From these warped areas is taken the wire model. From each several curves according to the current curvature are taken points. Just these points thanks to their placing in the particular virtual space are enriched by the connection with the height of the surroundings buildings and character of the local estate. Simultaneously in this phase is possible to work with the future functional ordering. By the compression of some point place is the designer able to influence the final structure.

These points are the enter points to the 3D Voronoi/Delaunay calculation. The script works on the principles of 2D Voronoi diagram – the perpendicular to the lines determine the planes. The tabs which are close to the enter points stay, other parts of the plane are cleaned. In the 3D Voronoi it is made by a sequential parabolic spiral.

The result of the computer calculation is the ideal structure similar to foam cell structure. They are for the particular entering point lay-out the most optimal solution – both the spatial and static arrangement.

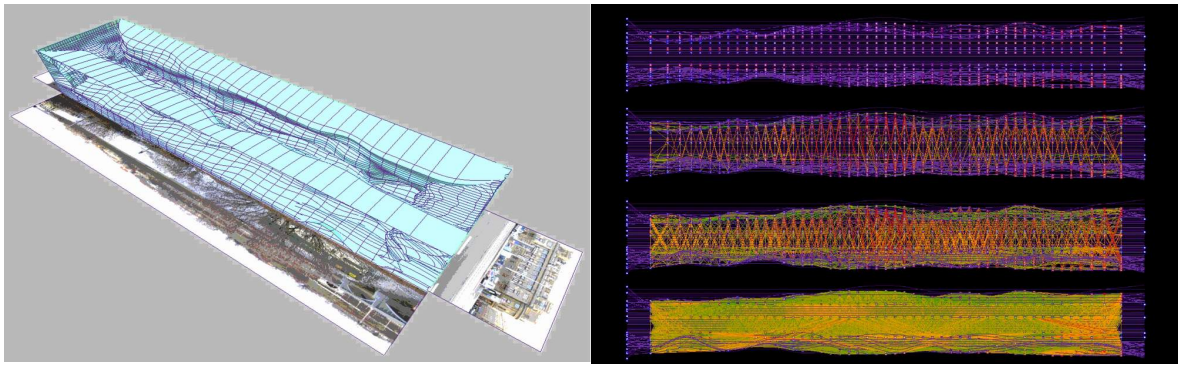

Fig. 3 3D virtual parametric model of the particular building site and generating the structure according to the levels of the algorithmic script.

4 3D CAVE examination

In this phase is possible to analyse the coming up volume in the 3Dcave space by special glasses and joystick. You can move in virtual space in view of the future user of the building. This analysis help the designer to find the most optimal solution from the user‘s horizon.

A Cave Automatic Virtual Environment (better known by the recursive acronym CAVE) is an immerse virtual reality environment where projectors are directed to three, four, five or six of the walls of a room-sized cube. The name is also a reference to the allegory of the Cave in Plato's Republic where a philosopher contemplates perception, reality and illusion.

The CAVE is a 10’ X 10’ X 9’ theatre that sits in a larger room measured to be around 35’ X 25’ X 13’. The walls of the CAVE are made up of rear-projection screens, and the floor is made of a down-projection screen. High-resolution projectors (the University of Illinois uses an Electrohome Marquee 8000) display images on each of the screens by projecting the images onto mirrors which reflect the images onto the projection

screens. The user will go inside of the CAVE wearing special glasses to allow for the 3-D graphics that are generated by the CAVE to be seen. With these glasses, people using the CAVE can actually see objects floating in the air, and can walk around them, getting a proper view of what the object would look like when they walk around it. This is made possible with electromagnetic sensors. The frame of the CAVE is made out of non-magnetic stainless steel in order to interfere as little as possible with the electromagnetic sensors. When a person walks around in the CAVE, their movements are tracked with these sensors and the video adjusts accordingly. Computers control this aspect of the CAVE as well as the audio aspects. There are multiple speakers placed from multiple angles in the CAVE, giving one not only 3-D video, but 3-D audio as well. [2]

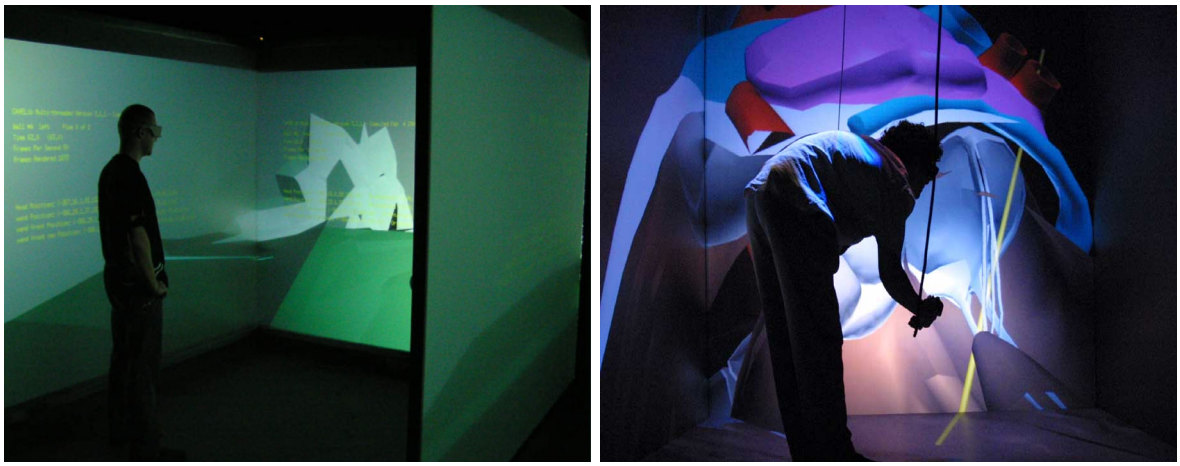

Fig. 4 3D CAVE structure presentation. FEL CVUT, 2008 Prague

5 The secondary Voronoi/Dealunay script

In this phase is necessary to the plate girder form cells cut opening. According to the sun analysis for particular spaces with particular functions is determinated the coefficient. This coefficient determines the number of the entering points for the secondary Voronoi calculation. This script work just on particular walls or cell surfaces of the structure. Making openings in this process ensure the light comfort inside the gallery.

6 Rapid prototyping – to get virtual model into reality

Not only for digital architect is important how to present their idea to the audience. For digital architect, who works in the virtual computer space is necessary to have some possibility to transfer the numbers into real world. One other of the possibility next to 3D Cave is rapid prototyping. Rapid prototyping is the automatic construction of physical objects using additive manufacturing technology. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Today, they are used for a much wider range of applications and are even used to manufacture production-quality parts in relatively small numbers. Some sculptors use the technology to produce complex shapes for fine arts exhibitions. [3]

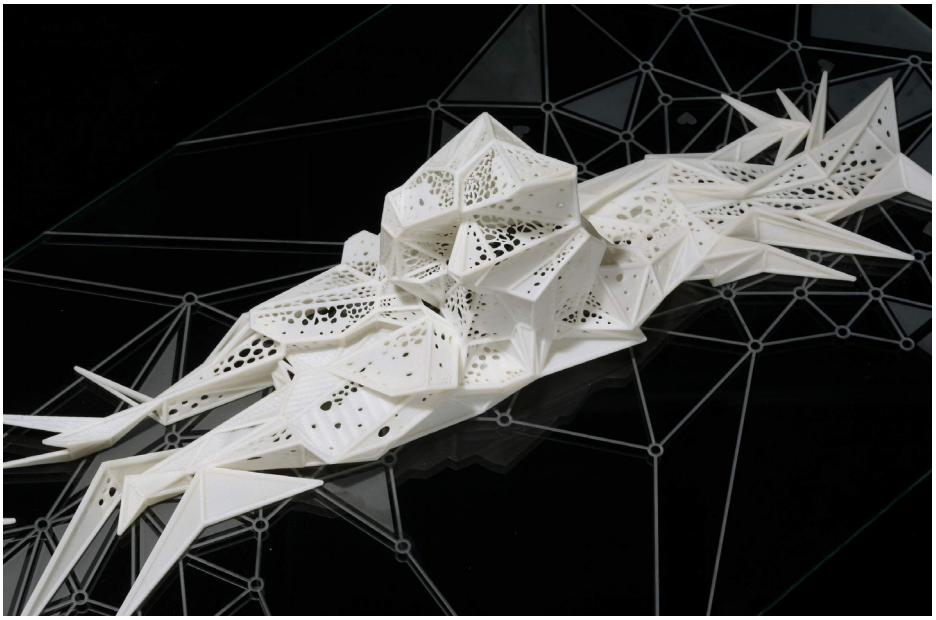

Fig. 5 Rapid prototyping, Diploma project Nina Hedwic 2008, printed by Tomáš Medek rapid-prototyping, laser-cutting, 3D Studio FVU VUT Brno, photo: Miloš Sedláček

7 Parametric design

The algorithmic digital architecture is architecture rising on the base of some rules, the rules with exactly programmed process – scripts and works with parametric models of buildings. Similarly to life organisms who are the mirrors of the informations loaded in DNA are buildings the mirrors of the data written in the script. Parametric design is the method of design, in which is used the digital technology and software, which by the entering data and parameters generate the possible form of future building. Parametric design is dynamic, open, flexible, is able to react on change during the real working time, use the feed – back. This point leads to optimalization of the design. It enables architect to work with actually endless numbers of entering parameters like climate conditions, material values, production and building process. Like life systems in the nature should also an architect project be able to interact with its environment, feed-back, cooperation and regeneration. These are some of the base conditions of sustainable design.

8 Conclusion

My task is to get to know and understand the connection between the rules, algorithms which stand at the start of process and the generated building shape at the end. Here is the presumption, that an architect in the role of programator or written of the script creates the rules of his project. Just the choice of the rules and parameters, which come into the algorithmic process, influence the character of the project. So if I understand in the digital architecture the whole process of generating building, I will understand the heart of the matter and the aesthetic of these type of project.

I will not be places only to the free form bubbles, but It will be understood like the reasonable consequence of the whole design process.

References

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