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Data Driven Parametric Design

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Abstract

The focus of this paper is that we want to give a brief introduction about the idea of Parametric Design (PD) and the use of data to inform the design process. The digital fabrication is not covered in detail in this document.

In the case study “Live Building” explains a sensory process. The project shows how to collect data, transformed and transported into a shape. Innovation is not only the approach of the draft, but the systematic procedure and the resulting diversity of solutions. The search for the geometric shape and the key to the concept will be answered in detail.

Keywords

Architecture, Computer Systems, Parametric Design, Sensor Technology, Urban Development

Introduction

"*Today, form is in any case no longer created from the fund of beautiful forms and given to an object. Instead form is invented, produced, generated in a computer, evolved, transformed*." (ARCH+ 159, 160: FORMFINDING, BIOMORPHIC TILL TECHNO-FORM, 2002)

In recent years, additional, new design processes have become available. These opportunities are supported by the digital and computer-generated world. Today, to a large extent, all complex projects can be modelled with digital procedures.

This multiplicity of applications should not be seen as overwhelming. Instead it opens up incredible creative scope for architects, designers, inventors and engineers.

There are countless opportunities in digital design. There are various mathematical, physical and biological experiments available for design. With the aid of parametric tools, simple to complex geometries can be realised.

Every design is based on its own rules and formulae which are mainly guided by a concept. What is unique is the way of designing with which variants of the parameters generated can be checked or added at will.

The use of electronics and sensory nodes allow for an informed design that is able to provide design responses that have relationship to sensor parameters.

1 Parameter

"By undergoing a process of parametrization, each object and its character becomes unique."

Parametric control may be intuitive or deliberate, thereby impacting the characteristics of body. Slight, localised modifications that affect the object's geometry are also available.

The choice defines a start and an end point and delivers a variety of solutions.

Precise measurement often limits the massive radius of possibilities. It is up to the designer and developer to stop the application at the desired point and to start a new trial.

The use of a parameter generates a diversity of aesthetic and geometric solutions. By doing this, it is possible to summarize the articulated geometrical algorithms in components and to modify them. The varieties carry the precision of rounded decimal places. These numbers put a plastic complexion on the project. Slight operations deform the being.

People decide about the system with *Correct* and *Incorrect*. The numbers give the project a three-dimensional face.

2 Formfinding

Having an understanding of creativity and geometrics is an advantage. One should never lose sight of the main task. There is a danger of getting lost in complex geometric structures and amorphous figures.

Experimentation and research are a continuous structure of the system.

Many questions concerning the context of the definition of shell, skin and shape, arise.
In order to simplify the process, efficient systems are created. A convincing piece of art results from a profound path and offers a number of structural solutions.

It is advisable to have one's own ideas about design and to understand the form as a whole and its dependencies. To interpret and analyze the perception of an object. The contours and structures become visible with a single division.

One crucial factor in design is the combination of dimensions, distances and proportions. It is important to find order even in complexity. The relationships of the dimensions characterize the appearance of the object.

The parametric work checks the combinations of the parts in terms of their order or disorder. Imposing grids and removing them at the same time. Displacing modules vertically or horizontally. There are elaborate mathematical methods available for scaling, deforming, stretching or rounding out the body as a being.

Whether or not the additional factors in the universe of the system of coordinates make their mark depends on various criteria of the design. The creator controls the variations from the basic form and affects the future path of growth.

The transformation of a body, this condition of morphology, tells a story from start to finish.
It is up to the creator to breathe life into the form.
(THOMPSON D'ARCY WENTWORTH: ON GROWTH AND FORM, 1917)

3 Research

The few elements space, time and matter - enabled the evolution of a world of increasing complexity. All energy and matter hit the world with the big bang. However, at first, as an amorphous appearance, without any structure. Only gradually did both arrange themselves to a newer, more refined system. Although the same laws have applied since the beginning.
(GEO WISSEN: CHAOS + CREATIVITY, 1993)

Where to start?
Which influences are picked up?
Which are the criteria that are used?

Given data, information, programs, colors, pictures or systems, are a great help. Inspirations, visions, pictures, movies, dreams, too. This lot of ideas is constantly summarized and evaluated according to personally defined or subjective selection procedures.

Influences can be picked up anywhere, anytime: including *algorithmic geometry*, *biology*, *computer systems*, *folding* (*Origami*), *natural phenomena*, *physical operations* and *sculptural art projects*.

For instance, the algorithmic geometry is applicable to modern engineering, robot technology, mathematics or computer aided design. Often the output is an answer to a specific request concerning objects.

The subjects can be approached in the studies in an interdisciplinary way. Shapes, geometries or colors are used by diverse sciences in a different context.

By establishing a library it is possible to save all collected information in bookmarks and to connect them. The server farms and clouds of today can manage a vast number of data.

4 Data

Data is abstract, it is vague can be obtained through several methods, but currently we rely on precision and accuracy of data that is given to us by institutions and in a way, people are renouncing the right to evaluate the data and to challenge what is being provided. In many cases, the producers of data are not the same people using them. The act of capture data is sensitive to many factors and analyzing this act is relevant to the user of the data. When the data capture is made by sensors, it is important to determine how were the sensors placed, in which position, orientation and which materials were used to position sensors. The influence of external factors can produce a series of biased data that may harm the results of what relies on that data.

Considering the right conditions of data capture and reliable data, the digitalization of it and computation render with new fields of exploration. With further help of the computer, people are able to parse the information and externalize it, bringing more consciousness to what is around us in a moment which most of the data is captured from people that are not aware of that.

Currently the majority of people's activities are mapped by institutions that want to understand the more as possible from the behavior of the population as consumers or as citizens to generate new businesses opportunities or to develop new ones or to achieve new standards for existing practices such as; architecture, urbanism and design.

5 ASK Ambient Sensor Kit

About

The first ASK was developed in august 2010. It was part of the *Live Parameters* workshop that happened in Barcelona. The kit was developed by *Luis Fraguada*, *Felipe Pecegueiro do Amaral Curado*, *Alba Armengol Gasull* and *Oriol Carrasco*. It includes a temperature sensor, light sensor, motion sensor, noise sensor, and electromagnetism sensor. It is run by an arduino and can be used to control Grasshopper definitions through gHowl+Processing or Firefly.

The control of the data captured by the sensors is made with a computer, that was connected with the kit while it is sensing. The data from the sensors was stored in a spreadsheet while it could be visualized simultaneously. Besides, the data could be used as a live actuator for an existing parametric model or to any other actuator connected to the computer. <http://uask.it>

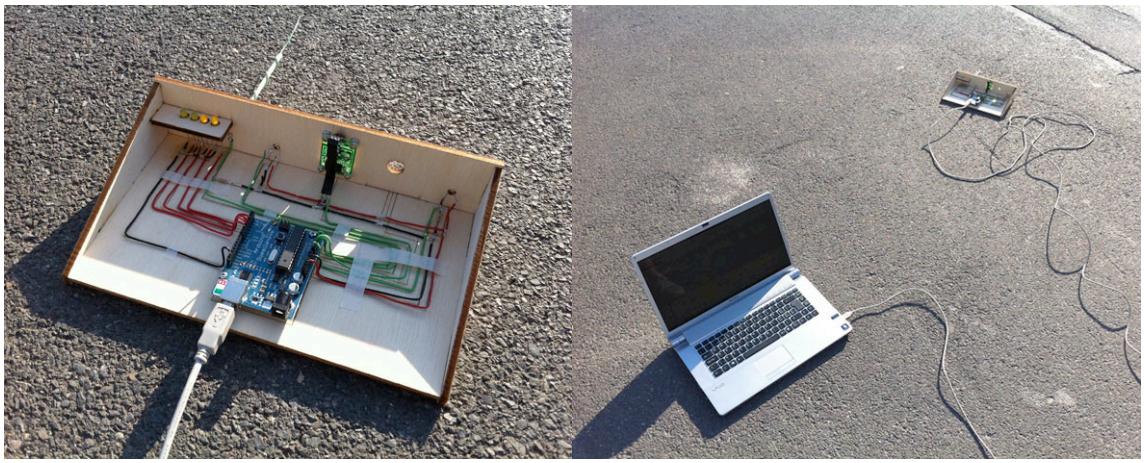

Figure 1: ASK version 1 (called USK Urban Sensing Kit back then)

Second version

Second version of the ASK was developed in march 2011 for the Smart Geometry Workshop, in Copenhagen. It added some features to the original kit, while it maintained some of the existing functionalities. The ASK 2 has a temperature sensor, a movement sensor, a light sensor, a CO2 sensor, a GPS. For communication with the user, it has a bi color LED that reacts to some of the kits functionalities and data logging capabilities via a Micro SD Card. The data captured by the sensors can be viewed in real time and it can be recorded in a text file. Besides, it is powered by batteries which allows it for an autonomous performance. <http://uask.it>

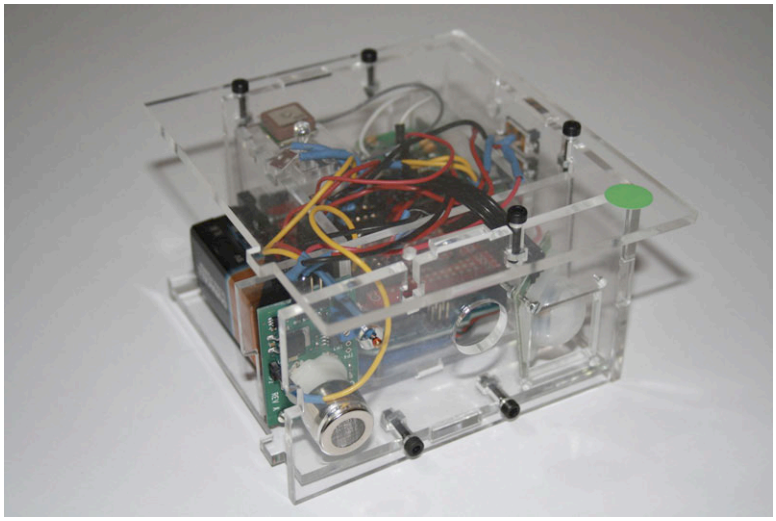

Figure 2: ASK version 2 (ASKIT)

6 Software

Grasshopper

For designers who are exploring new shapes using generative algorithms, Grasshopper® is a graphical algorithm editor tightly integrated with Rhino's 3-D modeling tools. <www.grasshopper3d.com>

gHowl

gHowl is a set of components which extend Grasshopper's ability to communicate and exchange information with other applications and physical devices. <www.grasshopper3d.com/group/ghowl>

Arduino

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. <www.arduino.cc>

Firefly

Firefly is a set of comprehensive software tools dedicated to bridging the gap between Grasshopper (a free plug-in for Rhino), the Arduino micro-controller, the internet and beyond. It allows near real-time data flow between the digital and physical worlds, and will read/write data to/from internet feeds, remote sensors and more. <www.fireflyexperiments.com>

Google Earth

is a virtual globe, map and geographical information program that was originally called EarthViewer 3D, and was created by Keyhole, Inc, a company acquired by Google in 2004. It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and GIS 3D globe. <www.earth.google.com>

7 Case Study

7.1. Live Building

Background

The project “Live Building” was developed at the IaaC Institue of Barcelona within the scope of a workshop LaN Live parameter with the support of Luis Fraguada and Monika Wittig. <www.livearchitecture.net>

How to collect Data?

An essential component of the process was the connection of data of an urban construction and an architectonic body. By using *ASKIt* it was possible to absorb the diverse results like temperatures, movements, lighting conditions, electro magnetism from the environment.

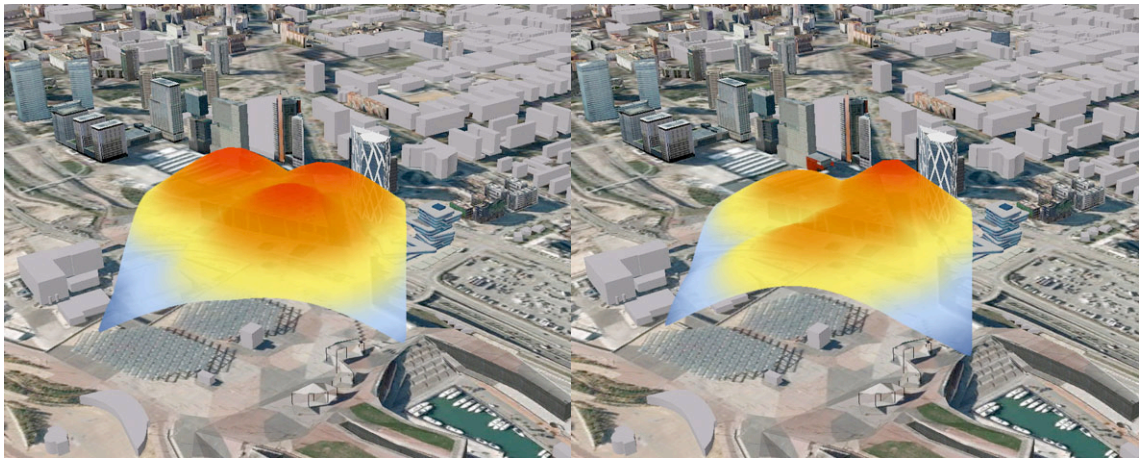

Figure 3: Light Morning and Afternoon

The chosen location was in the outskirts of Barcelona, in the triangle of the main roads Diagonal Avenue, Rambla de Prim and Ronda Litoral. Here the famous building the *Forum Barcelona* (by Herzog & deMeuron) is situated.

The data was captured in different measurement sessions, in which an external gps and compass devices were used to determine the position on earth and the orientation of the sensors in each capture session.

Each data capture session last for about 15 minutes, they happened in 2 consecutive days in morning and afternoon in the same position and orientation.
The sensor kits used on the data capture sessions are based on open source electronics, they use the Arduino board as the platform to collect the readings from the sensors. The Arduino board supplies the sensors with a 5 volts current and each of the sensors in the kit reacts to the environmental conditions by outputting a different voltage back to the board.
The Arduino reads this voltage difference and through algorithms that are programmed in the board, the data is transformed into information.
The board is also programmed to output the data from the sensor in a constant order. The sensor kits are connected to a computer through a USB cable and the readings from the sensors are printed on the serial port in the computer.

With gHowl, a plugin for Grasshopper, it is possible to read what is being printed on the serial port by the kits and manage the information to be stored in a data sheet in which the readings from the different sensors are placed in different columns. With all the data on the spreadsheet still with the gHowl plugin, it is possible to bring this data back to Grasshopper and manage it in order to develop visuals for the captured data or for the direct application of the data into a computer model.

To receive an exact orientation for the *ASKit*, a compass was made use of.
The displayed numerous and physical values on the computer were saved on a datasheet.
After using the programs *Arduino*, *Firefly* und *gHowl* the information was forwarded to the 3D modelling program *Rhino* and *Grasshopper*. (PAYNE ANDY, LIFT ARCHITECTS: The Grasshopper Primer - Second Edition, 2009)

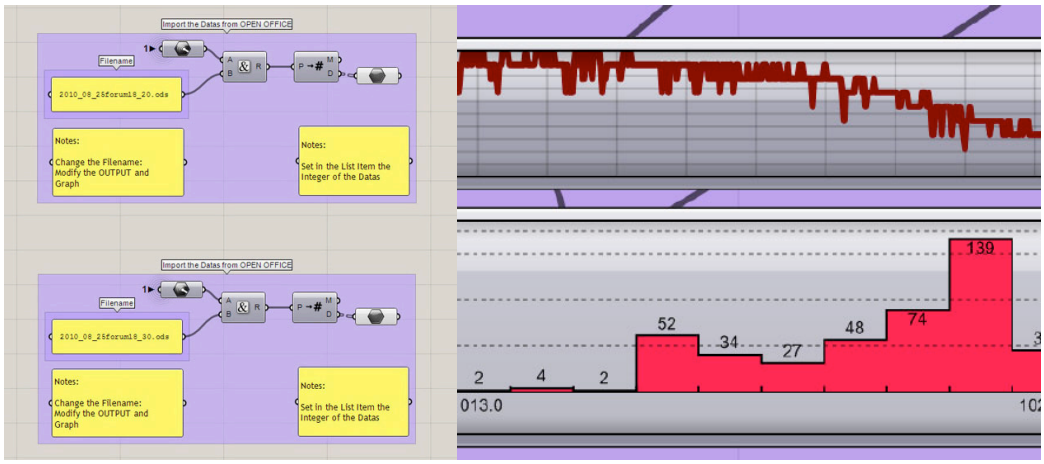

Figure 4: Collect and interpret data in Grasshopper

Concept

The works of Paul Broukes (Research Associate Professor at the UWA University of Western Australia) have given a precious ground and inspiration to this project. His geometric researches were very important for the development of it. Eventually we found paradigms in the classical fractal. In the end, an appropriate overall project was to be made out of exact scales and copies. <http://paulbourke.net/fractals/ifs_hedgehog>

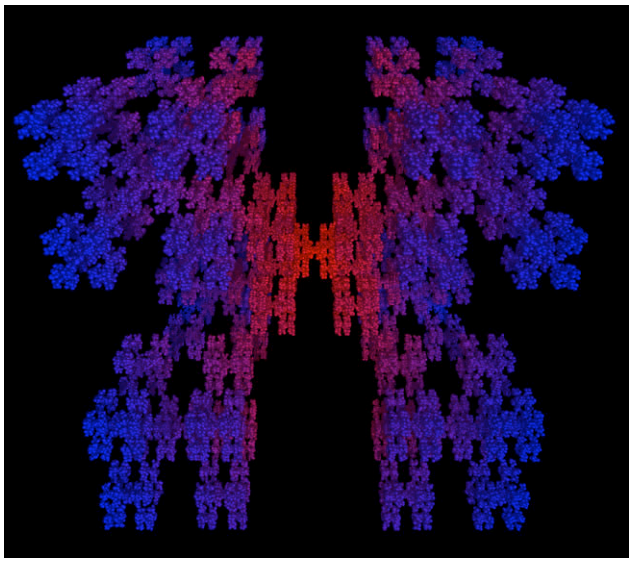

Figure 5: Fractal, 3D IFS Hedgehog (PAUL BROUKE)

3D curve

A skeleton was created by constructing a floating 3D curve within vitality. The perimeter were restricted by defining the width, length and height. The description (Figure 6) shows how the lines wind up in spirals and logarithms. This linear concentration and overlapping was a deliberate reaction within the process of design. The imaginary line was controlled by a code parameter and reacted to the environment intuitively.

Cubes

The knots on the three dimensional lines served as further decisive factors. The cubes stood for the architectonic basic element. The objects were placed on the lines generative and could be added optionally.

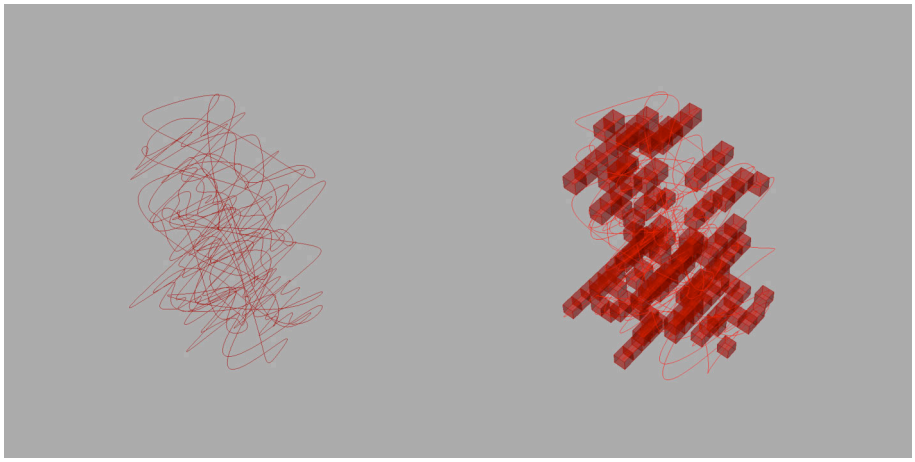

Figure 6: Cubes along the curve (LIVE BUILDING, 2010)

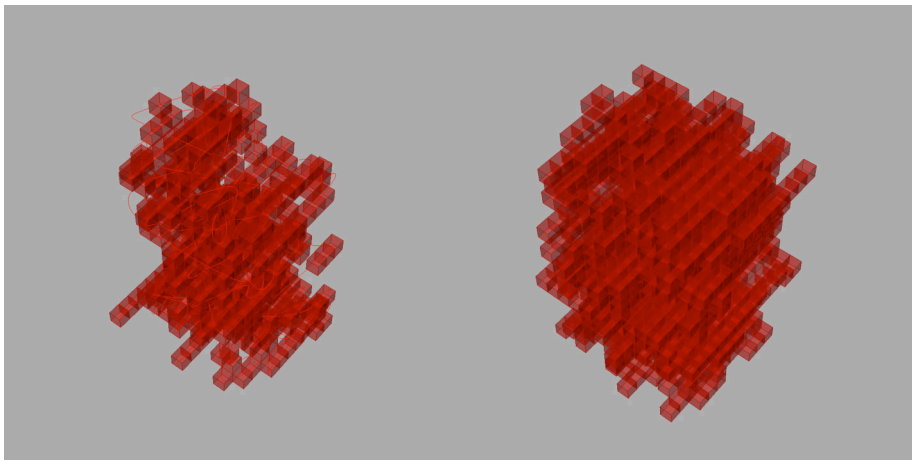

Figure 7: Cubes along the curve (LIVE BUILDING, 2010)

Laplacian smoothing

To finally give the shape a plastic and organic surface, an algorithmic definition was included. The instruction is called Laplacian smoothing and smoothed away the edges. (VOLLMER J., MENCL R., AND MÜLLER H.: IMPROVED LAPLACIAN SMOOTHING OF NOISY SURFACE MESHES, 1999)

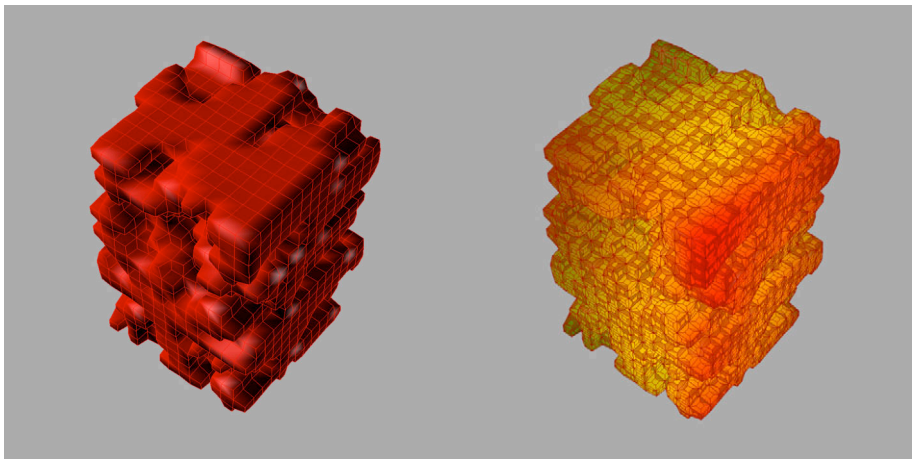

Figure 8: Lapacian smoothing, Visualisation Datas (LIVE BUILDING, 2010)

Lasercutting

Due to the complexity of the version, we chose to produce the project by laser procedure. The outlines were drawn conventionally in two dimensions and subsequently transferred the code to the machines.

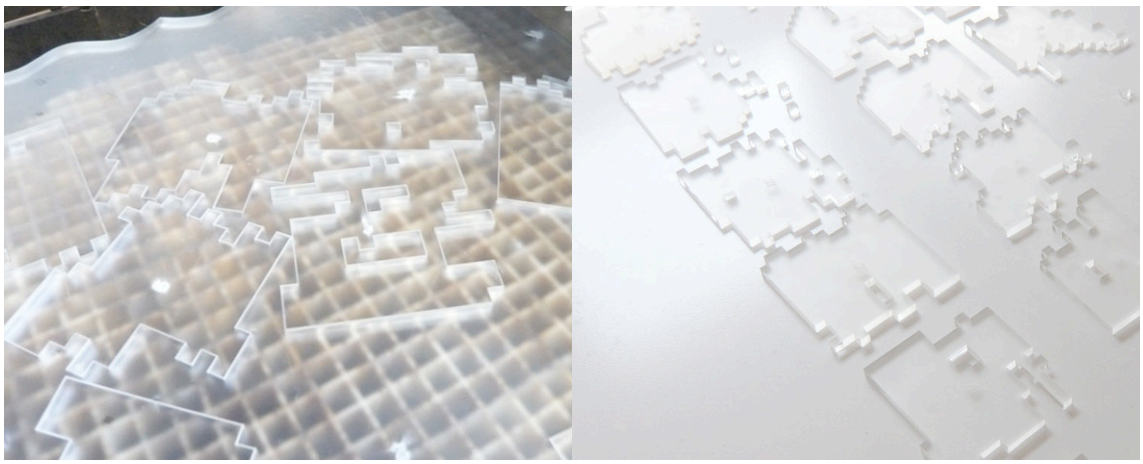

Figure 9: Lasercutting (LIVE BUILDING, 2010)

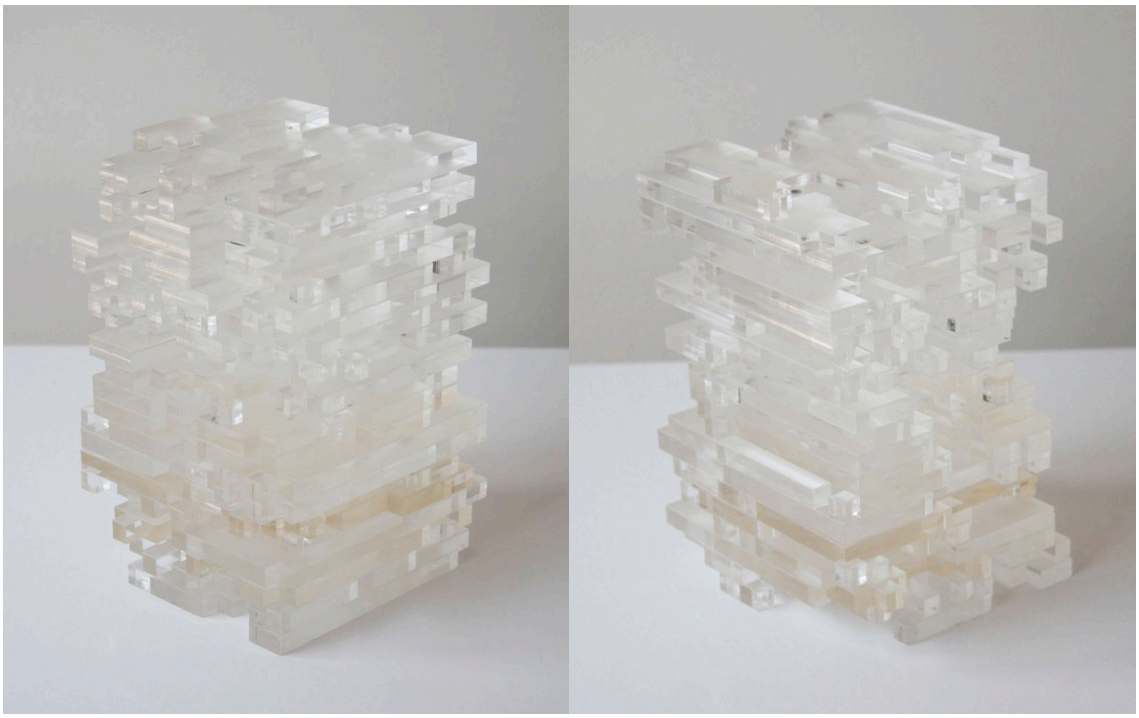

Figure 10: Model Fiberglass (LIVE BUILDING, 2010)

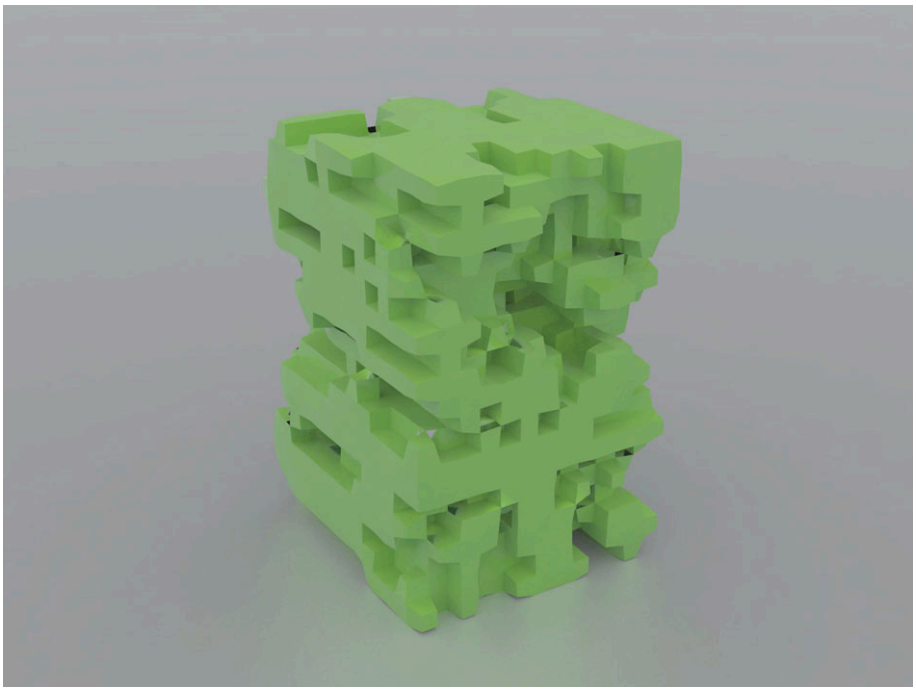

Figure 11: Rendering (LIVE BUILDING, 2010)

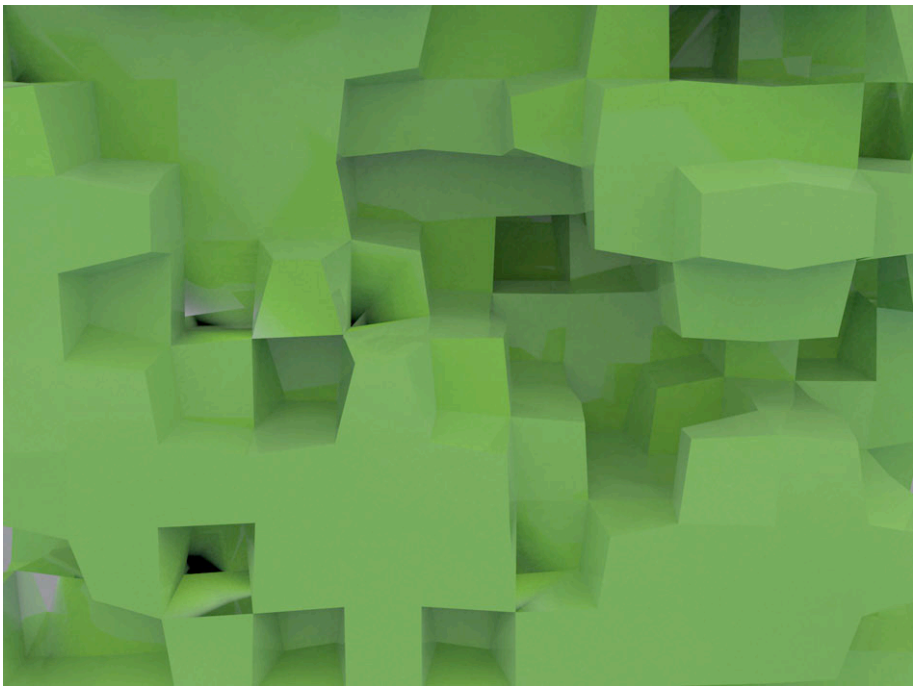

Figure 12: Rendering (LIVE BUILDING, 2010)

Conclusion

The sensoric methods create innovative areas within the process of development. The influence of these technologies enable the evaluatation of statistics or analyses from fields of topology, biology, physics and sociology. This additional value will in future be very important for urban development or construction processes.

Live Building is an abstract execution of data into shapes without rules of construction. A clear room schedule, materiality and usage are absent. *Nevertheless, the plan stands out within the scenario and breaks open space to research.*

8 Fiction

8.1. Design processes with brain data

“During the first performances - the body extensions - the balance between human and space is sounded. During the later compositions of space the human body is replaced by minimalistic performed kinetic sculptures“. (DANIEL DENNETT)

In this system, the human being with his past, present and future life in its entire complexity plays a significant role.

On the way through life the individual is shaped by influences, destinies or needs. These constellations modify the individual«s environment and housing. Depending on the phase of life we are in, we need more or less space, more or less light. We seek strict, clear forms or amorphous, organic structures.

Flexibility is a crucial factor in this regard. In mathematical terms we use the descriptions parametric or generative. We mathematically describe the expression as parametric or generative.

The connection to the memory and it‘s emotions is an important feature. It mirrors a personal signature. The measuring case applies to all action and is connected to a program in order to provide a basis for the system.

An unlimited vocabulary of senses, impressions and vibrations arises and can be perpetuated on a recorder. A new part of creativity is initiated. The recordings are a kind of new life form that project a connection between real time and a plastic reality. A piece of work which lies between day and dream evolves, everyday life being the field of inspiration.

Scenario

"A fictitious scenario can be that the human being is able to generate the object of his housing or provide an innovative basis for digital designing."
(DU MAGAZIN: REBECCA HORN, FINE MECHANICS FROM THE SOUL, 1996)

The architect as a scientist determines the scope and the parameters of the project. The room schedule and the complete information is transferred and compiled by the computer. The field of neurotechnology includes innovative methods of transferring these data to the machine.
The process is of a plain personal nature and combines fictitious components.
The interdisciplinary procedure mediates a creative range in order to create a digital flow between the human being and an object. The developer defines the structure of the saved references. <www.eyewriter.org>

Where should the biosensors be placed?
Which information does the computer compile?
Can this system be adapted to entire population groups?
What does the 3D grid look like?

Figure 13: Waiting for the end (LINKIN PARK, 2010)

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