THE USE OF PARAMETRIC METHODS AS DESIGN TOOL IN ARCHITECTURE

The aim of this text is to explain the potential and role of parametric methods in an architectural design process based on a student housing design proposal investigated during the 2016 winter semester at the Hyperbody design studio at TU Delft.

We will first provide some background by describing the current general perception of parametric methods in the field of architecture and clarifying common misconceptions. Second we will focus on the student housing project and its design process to offer a clear example of integrating parametric design methods in a useful way while relying on traditional architectural processes.

Parametric design and its common misconceptions

In order to understand what parametric design is, or more precisely a parametric model functions, it is fundamental to link these notions to a basic definition of the word “design”.

In his PhD thesis, Hudson (2010) summarizes “design” as a task that involves defining a description of a problem, then generating and searching amongst alternatives to find a solution to the problem. “Parametric design” is the process whereby a problem is defined using variables or parameters compromising an algorithm. By changing theses variables, a range of alternative solutions can be created, and based on defined criteria a final solution can be selected (Hudson, 2010). On this basis all design is parametric.

Antoni Gaudi’s parametric model of the Sagrada Familia

An early example for a design which is representative of a parametric model is the well known Sagrada Familia created by Antoni Gaudi in Barcelona. In his analogue design process Gaudi used the main characteristics of a computational parametric model (input parameters, equation and output). The upside-down physical models of his design took him years to build but offered more flexibility to explore his designs. Primarily, since every adjustment triggered the immediate physical re-computation of the whole system, it allowed him to derive the shape of the catenary curves (optimal arches) through the force of gravity acting on strings instead of recalculating each part of the geometry manually, while allowing him to be sure the whole structure would stand in pure compression.

Gaudi developed his method during the 19th century and even though it took him a lot of time to perfect his model, which appeared to be very inefficient during his lifetime, the general idea of using a parametric model appeared to be a promising concept for solving design problems in a responsive system. Although nowadays parametric models can be generated very quickly through the use of computers, which allow designers to exploit different variants of their projects very efficiently compared to Gaudi's process, parametric models also have their limitations and have to be used wisely in order to help the design process. Those issues will be discussed more in depth during the description of the student housing project below.

In spite of the fact that the concept of parametric design appears basic and is at the core of every design process, the opinions within the field of architecture concerning this topic are strongly divided.

Discussions with architecture students and professors who are not completely familiar with the methodologies of parametric design showed that many or even most of them reject the integration of computation into their design process based on what they heard about it.

This is mainly due to how parametric architecture is presented to the broader public. Most of the time the possibilities of creating complex, free-form or interactive projects with computational methods are put under the spotlight in order to promote computational approaches, which actually creates the false perception that the geometric complexity of these organic shapes is the only reason to use parametric design.

This false perception reduces the whole methodology to a simplistic generation of random generated shapes. Hence it is not a surprise that a lot of professionals tend to neglect this field of architecture before even hearing about its potential.

This problem is worsened by architects working in the computational design field who defend that the form of contemporary architecture should be "non standard", "complex" and "interactive" as for example Patrick Schumacher has done. Schumacher defines a new style of architecture called "Parametricism" which again defines parametric architecture more as an aesthetic than a methodology or a design instrument.

To state an example how professionally trained architects, even amongst teachers at TU Delft are sometimes surprised by their perception of parametric design the author of this report would like describe a discussion that took place during the Delft seminars of architectural design in the winter semester 2016. During the discussion a hyperbody student explained that a big part of the design process in their specific case, dealing with a student housing project, was actually understanding housing in general, trying to discuss questions like: How do people live nowadays in an era of shared economies (work, sleep, socialize, etc.)? How did the relationship between private, semi-public and public space evolve? How can we use our space in a smarter way, adapted to various lifestyles? But in order to be able to discuss those topics a range of precedents (Built projects, Utopic concepts, interviews, etc.) were used to understand the matter and build a solid starting point for further design decisions. Then as a further step, the students would use computational methods and parametric models in order to be able to translate various design problems and corresponding solutions.

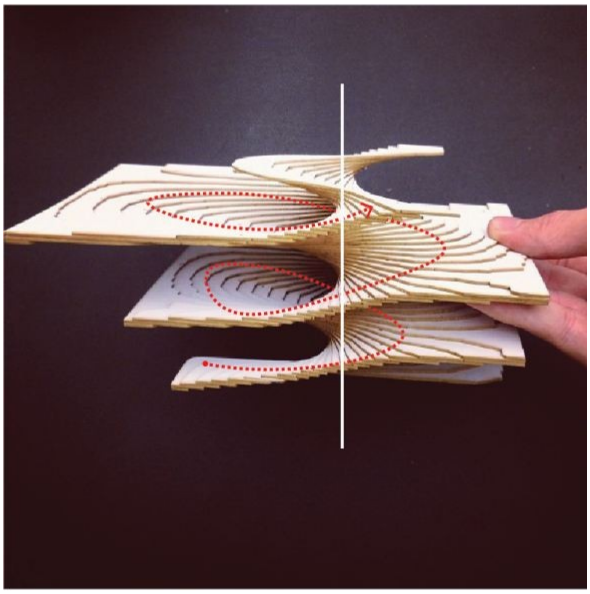
In reaction the lecturer seemed positively surprised and told the student that him/her was not completely aware of the fact that hyperbody students would also make use of "traditional" architectural methods and precedents to develop their designs.

Student housing project and the integration of computational methods

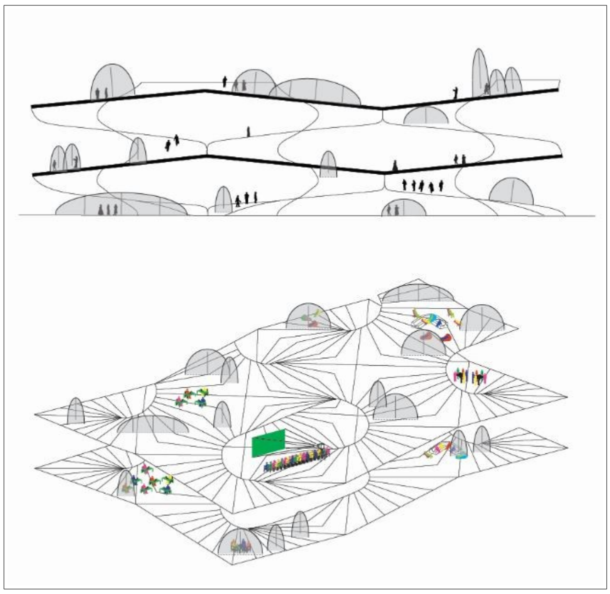
To be able to clarify how a computational work flow was integrated in the student housing project described above we will briefly introduce the main design concept and then focus on the parametric design aspects of the process.

The student housing is situated at the "green village" site at TU Delft, which is a new area of the campus where the university brings together research projects from diverse faculties in order to increase knowledge exchange and develop prototypes directly on site. This concept makes the site a very dynamic place where a variety of people from different backgrounds and disciplines come together to develop scientific innovation. Therefore the student housing should perform not only as student accommodation but rather as a connection point for the green village site and its surroundings, offering a range of public functions in a continuous interwoven space.

After an extensive analysis of the topic and diverse conceptual ideas the design group chose to base the spacial organisation of the student housing on the concept of a rheotomic surface. This specific kind of a minimal surface creates a vertical multiconnected space interconnecting steep (circulation) and flat (living) surfaces and therefore allows new ways of interaction suitable for the green village concept.



Rheotomic surface:
Continuous surface + structural sink holes



Conceptual drawing:
Interconnected space continuum

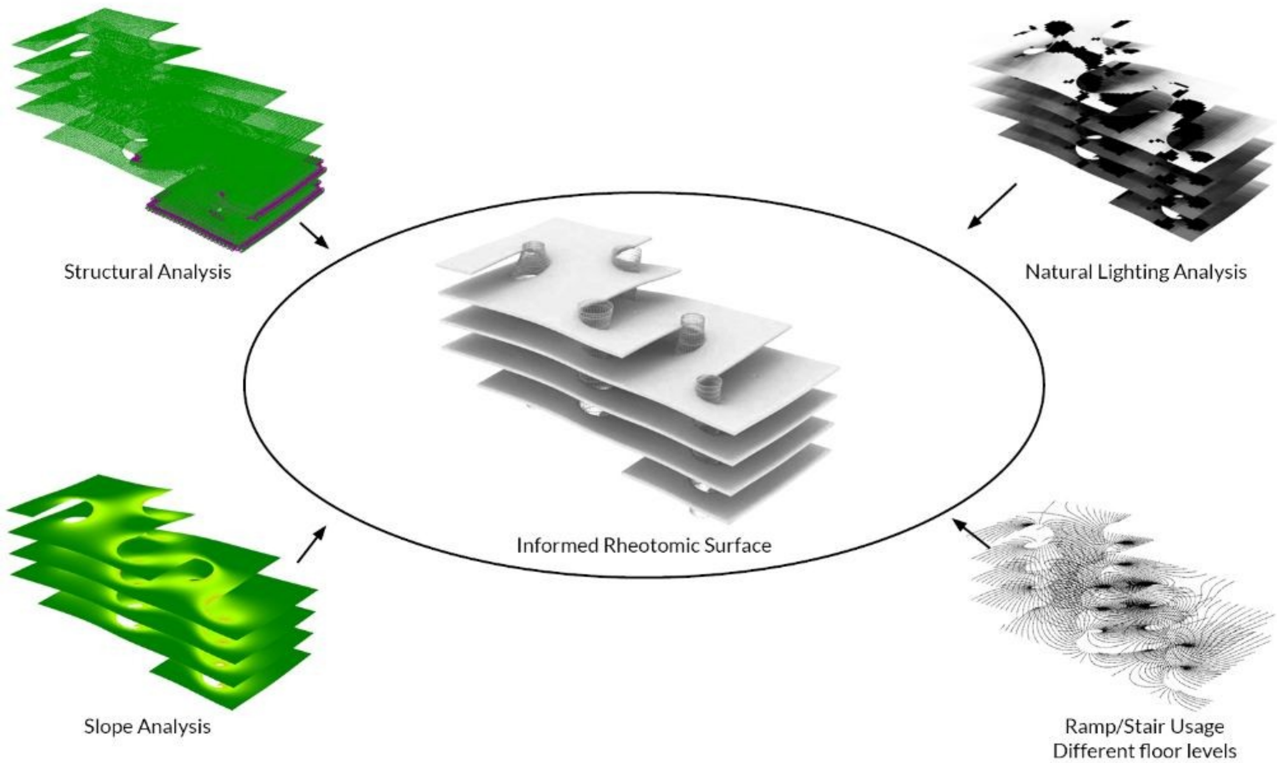
Computational / Parametric work flow

The general idea of this so called form-finding work flow is generating a starting geometry through the use of basic input parameters (height, width, position, etc.). Then depending on the task and the complexity of the concept, the next step is adding layers of "tools" which would allow the design team to find the most suitable solution.

In order to be able to work with a rheotomic surface the student team decided to translate the geometry using a parametric design software called grasshopper.

The first step in this process was to create the geometry based on the mathematical definition of the rheotomic surface and define basic input parameters. Aside from the standard input parameters such as size in x, y and z direction or number of levels within this boundary, the rheotomic surface is defined by sink holes who depending of their number and position change the geometry and connectivity of the surface.

At this stage the design team can grasp an intuition about the potential of the variation of the starting input parameters, by quickly manipulating the size and position of sink holes and outputting a range of very different surfaces.



But to be able to understand the changes made in the first step of the process not only in an intuitive and subjective way, a second layer of tools has to be added to the process.

In this case the design team decided to add analytic tools, that illuminate the precise changes of the rheotomic surface in response to variations of the input parameters.

The first basic output parameter to be read is the area (m^2) and size (m) of the surface to have an understanding of volume and floor heights, making it easy to see if the scale of the project is adequate to the initial brief.

Furthermore, a key parameter of a rheotomic surface is its continuous circulation area defined by different steepness. As different functions (circulation, working, reading, eating, etc.) allow different slopes mostly ranging from 1% - 10%, a slope analysis tool was added to the algorithm to help visualise the steepness of the surface in colour gradients.

Following a similar logic, light and structural analysis tool are added to the algorithm, helping the designers to precisely evaluate the potential and function of the rheotomic surface.

In a further step, the design team planned to manipulate the structure to create different surface treatments that would define a more precise zoning of the building, supporting its functional programming.

From these first two steps during the form-finding process we can deduct procedure which consists of creating geometry, adding "analysis tools" to the corresponding algorithm in order to understand it. Then if needed adding more complexity and refining the geometry according to specific constraints (function programme, climate, lightning, structure, etc.). This process can be repeated until a satisfying surface is achieved.

Limitations of a parametric design

While use of a parametric model can offer some clear benefits, this working method also has its limitations. One of the main differences between using a parametric model and sculpting the surface "manually" is flexibility on a local level. For example, if the design team would have to change the topography of the rheotomic surface in only one floor in a specific area to create a specially designed leisure area it would take a significant amount of time to extract the set of control points in this area from the algorithm in order to change their position to achieve the wanted topography. Whereas while working with a non parametric model the designer could access those points directly by clicking on them and precisely changing their position by numeric inputs which in that case would save a lot of time during the design process. One could probably argue that it is always possible to "bake" (i.e., output a current physical version out of the algorithm) a parametric model and then manually adjust the surface, but it would still become quite complicated to reparametrize (i.e., adjust the algorithm inputs) the geometry.

Choosing between a parametric or non-parametric model dependently on the design task is a crucial decision for the efficiency of the design process. Although in a lot of cases specifics of a project may drive the proper decision, we can define some primer factors that should influence such a decision. Geometry, scale and time available are key factors to consider.

Complexity of the design problem and intuitions as to the solution space may be particularly important. On the one hand, some geometries such as the rheotomic surface used for a bigger project are hard to grasp manually and working with a parametric model becomes crucial to get useful results in a reasonable amount of time. On the other hand, designing a conventional rectangular garden house with a limited amount of rooms does not necessary need a parametric model.

(Still it is important to underline that even if could take more time during the design process, a parametric model could generate some interesting outcomes for example in case of the lighting optimisation of the rectangular garden house, but discussing this topic in depth is out of the scope of this report)

Conclusion

Analysing the current perception of parametric design in the domain of architecture shows that the field is strongly divided in two main camps. On the one hand side architects interested in the realm of various computational methods and their potentials of developing new working methods and on the other hand side professionals who neglect the computational methods because of various reasons. An important factor why a lot of architects still ignore computational architecture is how these new ways of working are presented to the broader public (often also in academia), defining them as tools to solely create complex and random geometries that are purely formally driven.
Furthermore we understood on the base of a student project of TU Delft that computational methods and in that case specifically the use of a digital parametric model could be used efficiently as a tool in a design process and allow interesting new results for the field of architecture.
As computational tools become more and more accessible and easier to use, we can imagine a not so distant future where everybody could perform as an “architect” by swiping through their tablets. It would be interesting to think in a further step how the role of the architect will develop in this digital environment. We could argue that the architect would become unnecessary replaced by programmers, or in contrast architectural education could shift making architects specialists in algorithm design giving them even more control over the process?