The appliance of parameterization proposing urban projects:
A digital approach for sustainability

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ABSTRACT: This article aims to promote the discussion about the appliance of new features of parametric design and its possibilities within the proposal of urban scale projects that could consider sustainability issues. The digital tools now allow a new approach to shaping, which eliminates various geometric constraints imposed by traditional systems. This new paradigm encourages the use of a logic based upon mass customization, allowing the production of buildings and spaces increasingly complex and unique, both in terms of architectural form and as from the point of view of the space it occupies. The purpose of this paper is to contribute to the state of art of parameterization and discuss how this new feature can transcend purely formal questions and contribute to urban and architectural context that addresses to the logic of sustainability.
Keywords: Urban Design; Parameterization; Sustainability

INTRODUCTION

According to Mitchell (2008), the 1980s recorded major breakthroughs in the development of digital technologies applied to the projectual creation process. These technologies have been transferred from the aerospace and automotive industries to architecture and urbanism, and have transformed the logic of work and means of production. Tools for Computer Aided Design (CAD) software such as two-dimensional drawing, three-dimensional modelling and digital animation, as well as tools for Computer Aided Manufacturing (CAM), such as Rapid Prototyping (RP) and machinery Control Numerical Control (CNC), fundamentally redefined relationships between design and production to the extent that it integrated all the design process, from design to construction allowing one to start from a project and go as far as the manufacturing of architectural artefacts, using primarily digital information.

In accordance with Kolarevic (2005), the digital generation tools allow a new approach to shape, eliminating several geometric constraints imposed by the traditional design system. This new perspective encourages the use of complex geometries, or non-Euclidean, as NURBS surfaces, whose construction without digital support would be impossible or would require too much effort to run. At the same time, these production processes enhance computer numerically controlled logic based on "mass-customization", allowing the production of buildings and spaces increasingly complex and unique, from the point of view of shape and also from the point of view of architecture and of the space it occupies and delimits.

The parametric paradigm applied to large scale urban design is based on the argument that parametric systems make it possible to generate alternative compositions quickly by simply changing values of a specific parameter, and allowing one to obtain different scenarios that can be subsequently evaluated in order to facilitate decision-making during the design process. This is an overview open to interdisciplinarity and participatory work, encouraged by the facility of modifications and their ratings in the search for increasingly satisfactory results.

PARAMETRIZATION

The parametric concept corresponds to algorithmic built with a set of rules or logical relationships, geometric and parametric in a certain sequence, to solve a particular problem. It is also regulated by the declaration of the parameters of a particular object, and not necessarily by its shape. That is, the focus of interest is not the shape itself, but the parameters that generate it and how they can be used in order to produce cities and buildings that can contribute to sustainable principles. In this sense, the parametric design essentially presents a systemic approach that allows us to consider the relationships between the various elements of a system, enabling a genuine complex of interacting elements - a whole that is characterized by the interrelationship between the various parts constituents.

To Henriques (2010), parametric drawing and algorithmic design correspond to a set of rules or logical relationships, geometric and parametric in a given sequence, to solve a particular problem. For Silva (2010,

p.1), the Parametric drawing is regulated by the declaration of the parameters of a particular object, and not necessarily its form. That is, the focus of interest is not the form itself, but parameters that generate. Accordingly, the parametric drawing shows an essential systemic approach, since it allows to consider relationships between the various elements of a system so as to constitute a true complex of interacting elements - a whole which is characterized by the interrelationships between the various parts constituents.

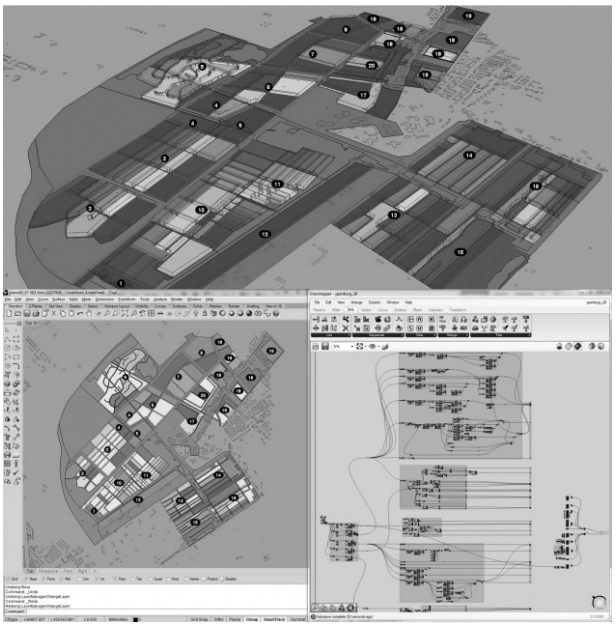

Figure 1: Parametric approach to understanding scale urban proposals developed by Beirão (2005). (https://http://abe.tudelft.nl/article/view/44)

According to Kolarevic (2000), a new function currently assigned to architects and urban planners is to develop computational tools for the creation process, known as Generative Design Systems (GDS). The GDS fall within the paradigm of evolutionary digital architecture, which proposes the evolutionary model of nature in order to develop design solutions, from the expression of architectural and urban concepts.

Still According to Kolarevic (2000), the GDS are computer applications that combine generative systems, simulation models and techniques for optimizing the performance of a building or structure. These programs guide the formal derivation from the evaluation of different solutions, through simulation techniques, and progressive optimization of the performance variables, using optimization algorithms, to improve architectural aspects. It is thus established an evolutionary algorithm that besides having the generative capabilities, which are assigned to systems, includes a performance feedback on their formal derivation, thereby giving him a goal and meaning that goes beyond the aesthetic field. This allows a new approach to design that completely reverses the traditional approach of iterative cycles of modeling - simulation - evaluation. An architect who uses these systems should first establish the goals that a given project proposes to solve by developing optimization and defining the objective function and its criteria. Then he should draw up a set of rules and that define the style to which forms should obey and the universe of possibilities that the generative process can explore, approaching the performance goals previously established.

SUSTAINABILITY PARAMETERS IN URBAN DESIGN

"Sustainable development is the development that meets the needs of the present generation without jeopardising the ability of future generations to meet their own needs." Bruntland (1991)

Therefore, sustainability is based on the dialectic between three poles: the economic demands, ecological integrity and social equity.

Major policy initiatives for sustainable urban development began in 1997 with the Kyoto Protocol and they have been increasing since then.

To discuss what can be parameterized in urban design, we first need to understand from the point of view of sustainability, the aspects involved in urban design.

It is necessary to understand the complexity of the city, with its network of neighbourhoods, their volumes and voids integrated with roads, axes and connections. To Perulli, (2012, p.15) the city is "network connected system, in which each part affects the whole, or rather a system of networked dynamic organization that changes in space and time".

To understand the city as an ecosystem, according to Chatelet (2013), is one of the contemporary theories that encourage reduced consumption, and the reusing of waste, creating a continuous and more balanced cycle as in an organism.

This reasoning applies at different scales in architecture. We can consider the individual, the house, the building, the block, the neighbourhood, the city, and the region. Finally, the idea of an urban area that needs to import their inputs and after these inputs are consumed have to be exported as waste is no longer acceptable.

For Chatelet (2013), if it is possible to recognize the variables involved and set weights and importance in accordance with the project interests, it is also possible to generate it through digital different alternatives that meet pre-established parameters. Thus, different generated alternatives can assist the designer in his decision-making at each stage of the project.

"Prediction is any form of process and future events knowledge related to the use of existing knowledge." (Cramer, 1999, p. 53)

According Perulli, (2012, p.7) from the XX century, the city lost a clearly defined shape, which was printed not

only in treaties of architecture, but in the mind itself of its inhabitants. For the author, "our era is characterized by the direction of flow," which requires different tracings from the circular or organic adopted before.

For Panerai et al, (2009, p.178) the issue of the urban fabric cannot be separated from everyday experience and the city. Building a city today is not limited to functionality, but means a willingness to deal with the shapes with their different qualities: proximity, mix and the unforeseen. He also highlights the importance of sustainable actions in urban design as a public area accessible to everyone.

The Panerai et al (2009) reasoning is reaffirmed by the European network for sustainable urban development, the Suden [http://www.suden.org] when it says that sustainable neighbourhoods should be "(...) designed according to the principles of the social and economic diversity of non-motorized mobility, with good access to public transport and also be equipped with many services and green spaces, improving the quality of life and local biodiversity."

To Pezzi (2007, p. 59) many urban decisions have caused lasting effects on society and quality of life for residents as well as on the environment. He considers that urban form is the result of a complex interaction between independent elements: weather, social, political, strategic, aesthetic, technical and normative.

Still for Pezzi (2007, p. 59-60) in urban scale, the need for fossil fuel and energy resources economy and the use of energy sources that are more respectful to the environment are increasingly urgent. On the scale of the neighbourhood, certain decisions can improve the local microclimate, protecting it from wind and excessive solar radiation, moderating the negative effects of urban conditions such as noise and air pollution and visual. But remember that energy efficiency is not a goal in itself but part of an integrated search for sustainable development.

Several bioclimatic principles for urban design were developed by Romero (2000) as well as by other authors. On the morphology of the urban fabric, Romero (2000, p.115) proposes an analysis for different types of weather, dealing with emphasis elements as: shape, streets, lots and size of public space.

From studies derived from environmental comfort it is possible to identify "parameterizable" data in different stages of the project. It is true that some of the guidelines adopted as principles, can be contradictory, such as, for example, indicating a implementation because of the wind and another because of heatstroke. However, the shape and performance of the constructions are crucial since the route can't meet all the requirements of the climate region. For Romero (2000, p.116) in order to correct or mitigate certain climate variables vegetation, water, shields, coats, and colours, can be used.

According to Romero (2000, p.116) the adoption of the general principles indicated, first requires a review of the climatic region, which can be made from the diuturnal variations in air temperature, the amplitude of these variations, the schemes of rain determining the dry or rainy season, the intensity of direct and diffuse radiation, the amount of humidity, the wind regime, the altitude and geographic location. In sequence portions of the urban space should be analyzed, since there are situations that are very different in the spatial structure, with the occurrence of differences between the elements of weather (temperature, wind and humidity) in different neighbourhoods, streets, parks, ponds, hills etc.

In summary, the principles for site selection should take into account the location, ventilation and sunlight and the morphology of the urban fabric, and can take into account the shape, radiation, ventilation, lots, the size of public spaces and the streets as in the example of Romero (2002) or coefficients of waterproofing vegetalization factor, connectivity, diversity and materials as found by Chatelet (2013).

It is up to the designer to identify the actors involved, decide on criteria and consider possible alternatives to each study. If possible to use parameterization, we defend the idea that digital tools are important allies in this process by providing agility and technical support diversity and complexity of the information involved.

URBANISM, PARAMETERIZATION AND SUSTAINABILITY

If the modern ideal sought a standard answer to many problems, a proper implementation of parametric paradigm in urban design can provide a specific response to each project situation, or even a multiplicity of solutions for the same issue to be evaluated by the designer in decision making process. In this sense, the emphasis escapes from mass manufacturing to mass customization and provides a new design approach that allows considering aspects of sustainability and appropriate simulating solutions.

For Beirão (2005), the task of designing plans for cities can only be improved if designers are able to understand some of the relationships between the components of cities during the design process. He calls these measurements as urban indicators. By calculating them, designers can grasp the meaning of the changes being proposed, not just as simple alternative layouts, but also in terms of the changes in indicators adding a qualitative perception.

In this sense, it is important to mention that a parametric approach to sustainable urban design should consider aspects that transcend purely formal issues, seeking to bring to the study design criteria such as density, impermeabilization, sunlight, shading, voids, green areas and ventilation.

To admit the parameterization as a logic that allows to obtain several variables in design, so as to an interpretation of optimized data to assist in decision making, means that the parametric process can be an important tool to aid design decisions in its different stages.

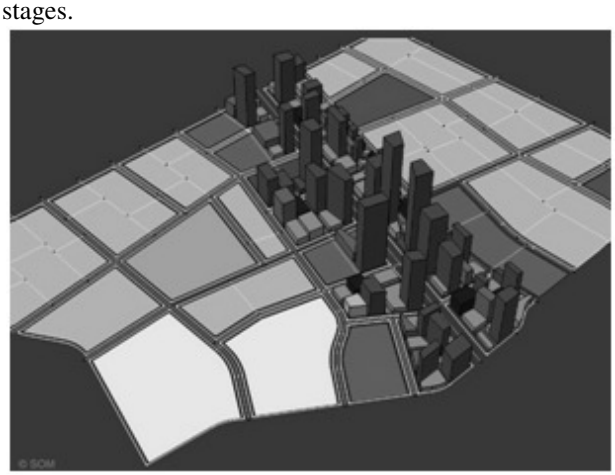

Figure 2: Parametric urban model: The geometries are automatically updated and all the tabulations are immediately recalculated, allowing for very efficient "what if" scenario testing. (https://www.som.com/video/parametric-urban-design)

According to Skidmore (2013), this logic means that the data that is automatically collected from the model can also include aspects like total Built Up Area (BUA) for the entire site, BUA for each block, Floor Area Ratio's (FAR) for each parcel, areas of land by use-type, areas of building by use-type, and a number of other useful metrics. Working with a fully parametric framework, makes possible modifying one input and rearrange the geometries of all the impacted streets, parcels, and buildings, that are automatically updated and all the tabulations are immediately recalculated, allowing for very efficient "what if" scenario testing(refer to in Fig. 2).

CONCLUSION

The application of parametric paradigm has been much more restricted to the field of architecture, and their incorporation into the practice of urban design is still being analyzed. As stated by Steinø &Veirum (2005), in recent years, various forms of parametric approach have been introduced in urban design strategies, so as to constitute a systematic parametric approach to urban design. Still for Steinø & Veirum (2005), it is important that the parametric urban design working methodology is not centred only on quantifiable data, but consider what should be the different parameters to be adjusted and why - a pre-requisite for all design decisions. In this sense, we must understand spatial and programmatic parameters, such as density, space and usage, as well as formal parameters as Cartesian geometry / organic, regular / irregular / or dense / sparse model high / low, among others.

The parameterization can be presented as an efficient tool for sustainable design as it allows constant evaluation of urban parameters that can be fed back on the results obtained at each step of analysis.
Whereas the architectural concept should be understood dynamically, this new work logic facilitates insertion and constant revaluation of the agents involved allowing an approach that is compatible with the concept of contemporary design.

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