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The Implementations of Parametric Design Tool in The Urban Environment to Achieve Quality of Life

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***Abstract*:** *Many tools for measuring the qualities of urban life have emerged in the past few years but the relationship between urban design qualities and physical urban features should remain integrated. There are mixed interdependencies between qualities with different proportions and values however, the urban design process is frequently misplaced to achieve these urban qualities. The main aim of this paper is to model the relationships between the physical urban design features which lead to the achievement of qualities of urban spaces and their complex relations and criteria.*

The research first analyzes the multiple connections, proportions and inter-relationships between the features of urban design based on a rating system that integrates the principles of smart growth, urbanism and green building such as the Leadership in Energy and Environmental Design (LEED). Next, Parametric design tools are then utilized to manage the complex interdependencies between quality of life values and the urban planning context. Simultaneously, these parametric design tools generate multiple solutions from the same relations in order to present an urban design process that achieves high quality of life.

The research suggests that the adopted tools and model could be implemented on a wider scale in order to generate alternative design solutions that are in accordance with the quality of life values and criteria. The formulated parametric model can inform the designer and decision makers to respond to the requirements of quality of life in their design process with computational design methods in an urban environment.

Keywords: *Urban design - Parametric design tools – Quality of life.*

1. Introduction

This case introduces the use of computational design tools in the domain of large scale urban planning through the exploration of a differentiated urban order functioning. Within a framework of overall coherence, the site is interpreted as an informational data field. In this particular example, a data field represents a set of points distributed on the site. A manipulative set of input parameters is derived from the quality of life conditions around the site. The output variables incorporate a distance value for each important point on the site to those of the influenced elements.

Using script-based techniques, values are translated into the urban and formal responses of building typology, height and connectivity. The use of multiple transformative building typologies creates an urban pattern bringing about variation within the urban field, whereas the continual shift between the solid building masses and the buildings with voids becomes the premise of the architectural condition. Hence, the design process focuses on the formal resolution of the multiple patterns that emerge from the site.

Embedding intelligence into the automatic scripting process would allow the creation of new types of urban spatial organizations and formations differentiated in response to quality of life condition forces. The output geometry can be tailored to the diverse contingencies of various locations. This empowers the computational

process by not only allowing it to manipulate the inputs for data generation but also trigger unprecedented responses. Once set up, the system can be used to catalogue multiple design variations in a short period of time. By altering the input parameters, it is possible to use it on the architectural as well as on the urban scale.

2. Parametric Design Tool

2.1. Associative Design Models

Associative design is based on parametric design techniques that exploit associative geometry.

- In parametric design, relationships between objects are explicitly described, establishing interdependencies between the various objects. Once variations between objects has been generated, it can be easily transformed and manipulated by activating these attributes.
- Different value assignments can generate multiple variations while maintaining conditions of the topological relationship, thus defining an associative geometry. Interdependencies between objects and object behaviour can be established under transformation.[1]

2.2. Generative Algorithms

Contemporary designers are dealing with 'Algorithms' as the model of computation to do their design tasks. An Algorithm is a set of rules and instructions in a step by step procedure to calculate and process data and do a defined task. For any piece of input data, an algorithm will perform its predefined operations and calculate the result. In this sense, a design algorithm will also provide a design output if being fed by relevant input information.

In conventional design systems, there were various parameters (i.e. Site, Program, Building Type, Facilities, Beauty, Structure …) which should be considered during the design process whereas in algorithmic processes it is attempted to transfer these parameters (input information) into algorithms to generate design solutions. What is currently known as Algorithmic, Parametric or Generative design software is the platform to do such design processes in computers via CAD (Computer Aided Design).

Algorithmic design has two main sides, one is 'Algorithm' and another one is 'Geometry'. Algorithm, like a recipe, manages and processes data, gathers input and provides desired output. Geometry is the ingredients where algorithms apply the recipe to them, and create the output product. Algorithmic design tools and any design medium in this field should provide facilities for both sides. [2]

2.3. Parametric Software

3D architectural computer models in virtual space are generally highly supple in parametric software like:

- Digital Project based on Dassault Systèmes CATIA
- Generative Components based on Bentley Microstation
- Grasshopper based on McNeel Rhinoceros,
- Solid Works,
- Solid Thinking. [3]

Grasshopper is one of algorithmic design tool, In contrast to the scripting platforms for algorithmic design, Grasshopper has a visual interface in which development of an algorithm could be seen like a flowchart. Beside other usual Windows menus, there are two important parts in the Grasshopper interface: Component Tabs and Canvas. Component Tabs provide all elements which are needed for algorithm or geometry purposes and Canvas is the work place, where to put Components and set up design algorithms.

An Algorithm is a set of tasks in order. It takes information, processes data, and generates result. Usually a component also takes some data from one/multiple sources and gives the result back (a very small algorithm). To set up a design algorithm, it is needed to provide data by relevant components and connect components together in the order of the task which they want to perform and get the result. So a design algorithm in Grasshopper is comprised of multiple components with their logical connectivity. The research uses grasshopper in the next case study. [2]

3. Case Study

3.1. Site Parameters (Inputs)

The research will investigate some of the site parameters (inputs elements) which mainly depend on the urban design qualities and changes within certain range. In addition to that the site parameters are divided into responding and influencing elements in the urban scale TABLE I. The interdependencies between parameters can easily connect by the parametric design modelling. Consequently these complex interdependences achieved the quality of urban life according to a based rating system that integrates the principles of smart growth, urbanism and green building such as the Leadership in Energy and Environmental Design (LEED). The latter recognizes development projects that successfully protect and enhance the overall health, natural environment and quality of life. [4]

TABLE I: Examples of inputs parameters

Responding elements	Influenced elements
Site area	Attractor points
Original grid	Streets
Networks with the urban fabric	Rivers
Buffering zone around	Green area
Gross building area	Industrial area
Building heights	Landmark
Building orientation	Lake view
Building voids	
Street width	

3.2. Concept of Distance

This catalogue of computational tools uses distance as a driver to achieve differentiation in a given field. The base setup includes a grid of points (represent a responding elements) and an influencing element “Figure” 1. Every point in a point field can be described as a numerical value. For example, by converting each point into a value equivalent to its coordinates X, Y and Z, each point attains a data set that can be classified within a data field. The design research focuses on the translation of local conditions of the site into data fields, which in turn become drivers for formal responses on the site allowing us to achieve differentiation within the framework of an overall coherent order.

The computational tools in this case study demonstrates the principle of taking distance from an influencing element to generate a series of responses. Although the variety offered by the computational tools includes shifting the position of points on the grid, scaling of elements and rotation all in proportion with the distance value of each point from the influencing element “Figure” 1, the different transitions allow us to create connections with its neighbouring points “Figure” 2. Moreover Voronoi cell packing is used as a method for space subdivision. The strength of the system emerges with a layering of multiple effects in correlation to one another. These tools are applied to the site where the influencing elements become the immediate context of the site.

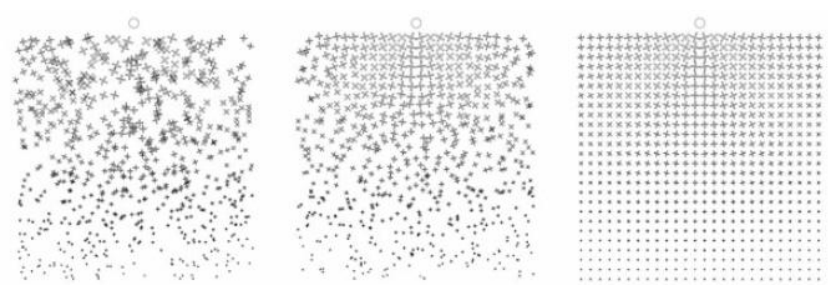

Fig. 1: Rotation and scaling of a component placed on points. [5]

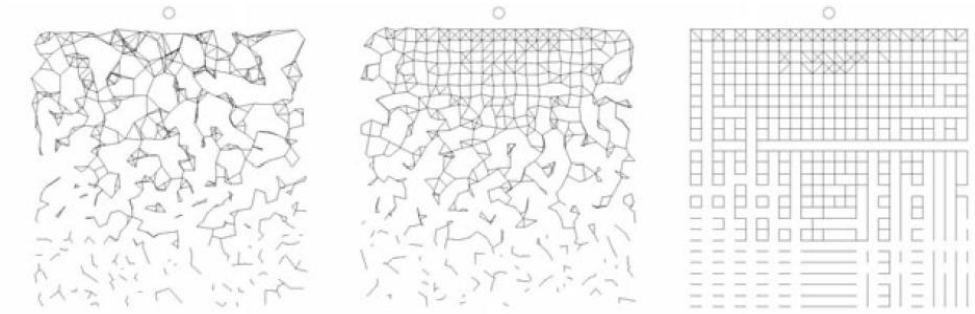

Fig. 2: Point connectivity pattern variation. [5]

3.3. Initial Setup(Methods)

Define influenced elements:

- Define certain area of the site (change parameters of the area)
- Define the numbers of point which represent the center of building blocks.
- Define the influence elements or points (blocks) related to site conditions TABLE I.

Define the site conditions (responding elements):

- Distribute the original grid by shifting the position of each point (center of grid) from its original location .The value of the shifting depends on the distance between each point and the influenced point. The degree by which the point shifts is observed when the points closer to the influenced block maintain their positions (min. shifting) whereas, as one moves away the pattern becomes more random (max. shifting). “Figure” 3
- Remap the distance meters all in proportion with the distance value from the influenced element.
- In order to negotiate the points into larger urban context we divide the site into cells based on the location of points. From the point set a packing of Voronoi cells is developed, where the density of the point reflects the size of each cell. “Figure” 4
- While the parametric urban model is built, it could also relate all the responding elements in proportion with the distance between cells and the influenced elements and with fixed relations with each other.
- All these proportions are mainly related to the quality of life relationships.
- For example, the interdependencies between gross building areas, street width, buffering zone, building heights, building orientation and court area has fixed relationships that can be changed with respect to the influenced elements. In order to simulate the values of qualities of urban life, the input values on the parametric modeling can be changed within defined range. “Figure” 5 “Figure” 6
- In response to all the previous relationships, changes in values are available with fixed relations in the whole modelling that can be applied to any different site condition and generate parametric design model with responding values to the qualities of urban life.
- Generate digital design modelling with fixed relationships and multiple solutions which create different parameters variations in the same relations, “Figure” 6. All interdependencies are fixed but all parameters can be changed based on site quality and condition. Relationships are defined related to the qualities of urban life with its changeable parameters and all values can be remapped related to certain parameters to achieve high quality of urban values with the same complex relations of quality of life indicators. “Figure” 7

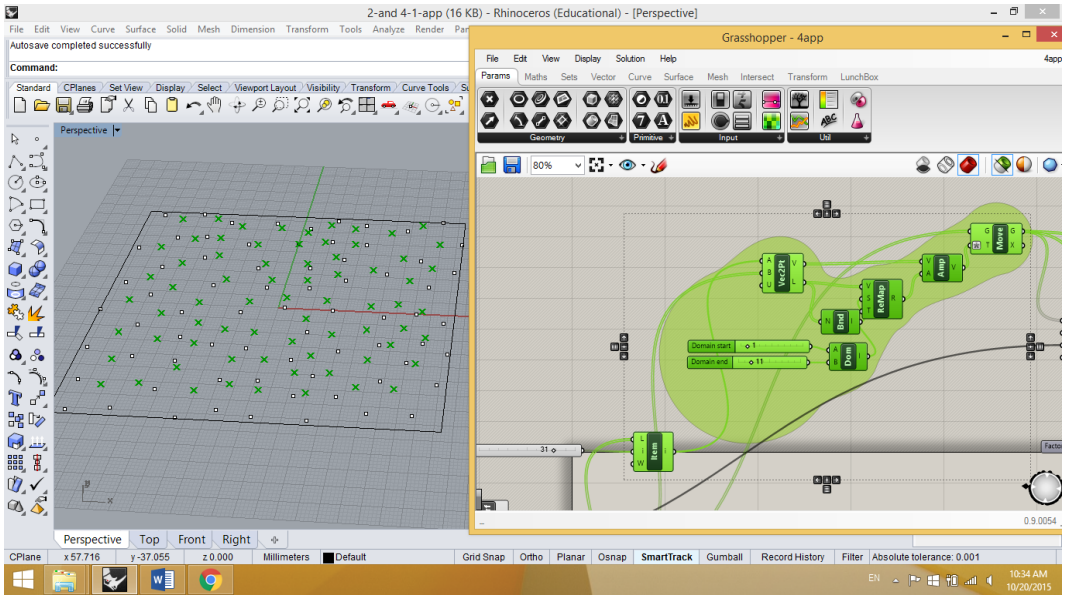

Fig. 3: Remap and shifting.

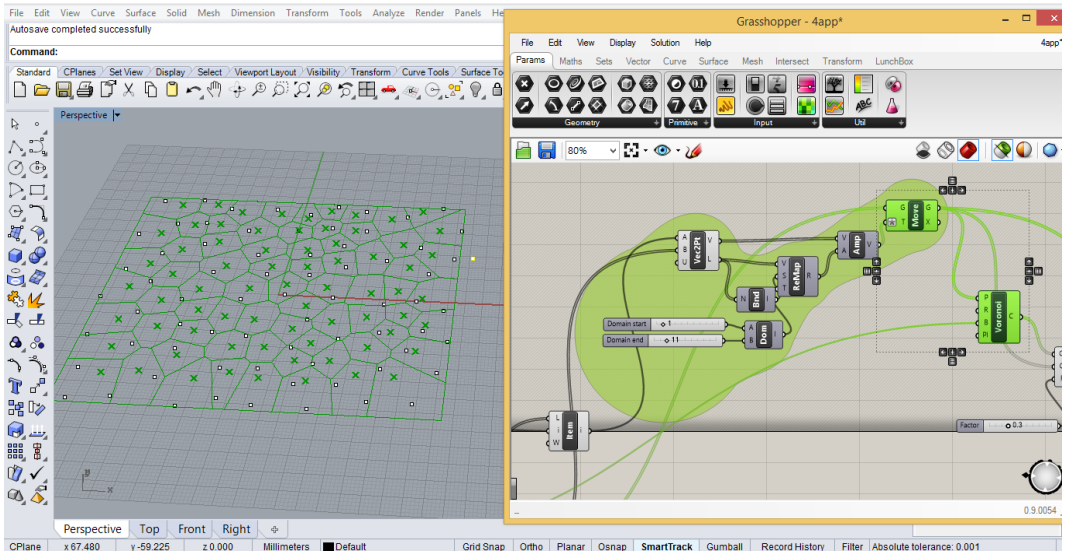

Fig. 4: Voronoi cells packing based on the point grid.

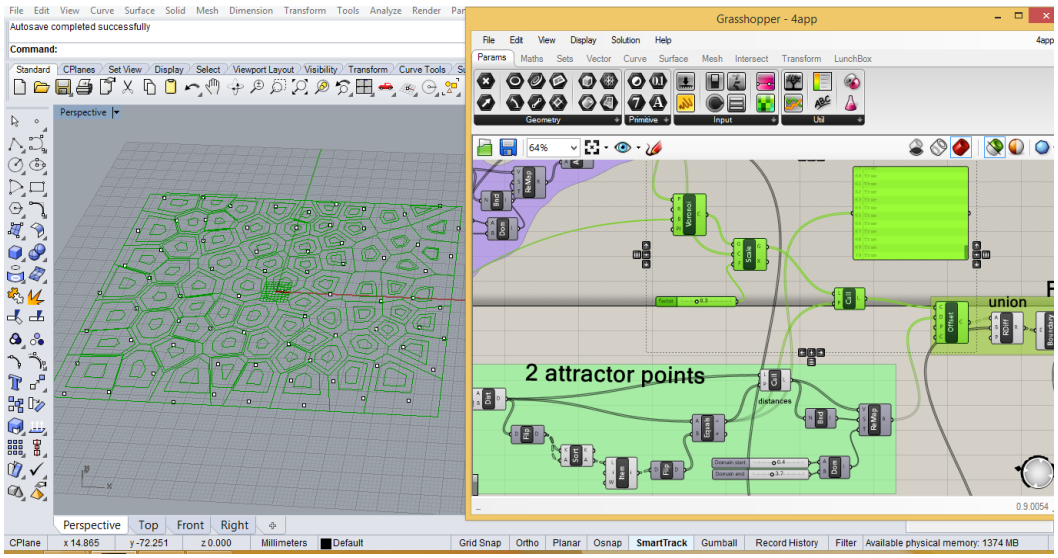

Fig. 5: Scale and offset.

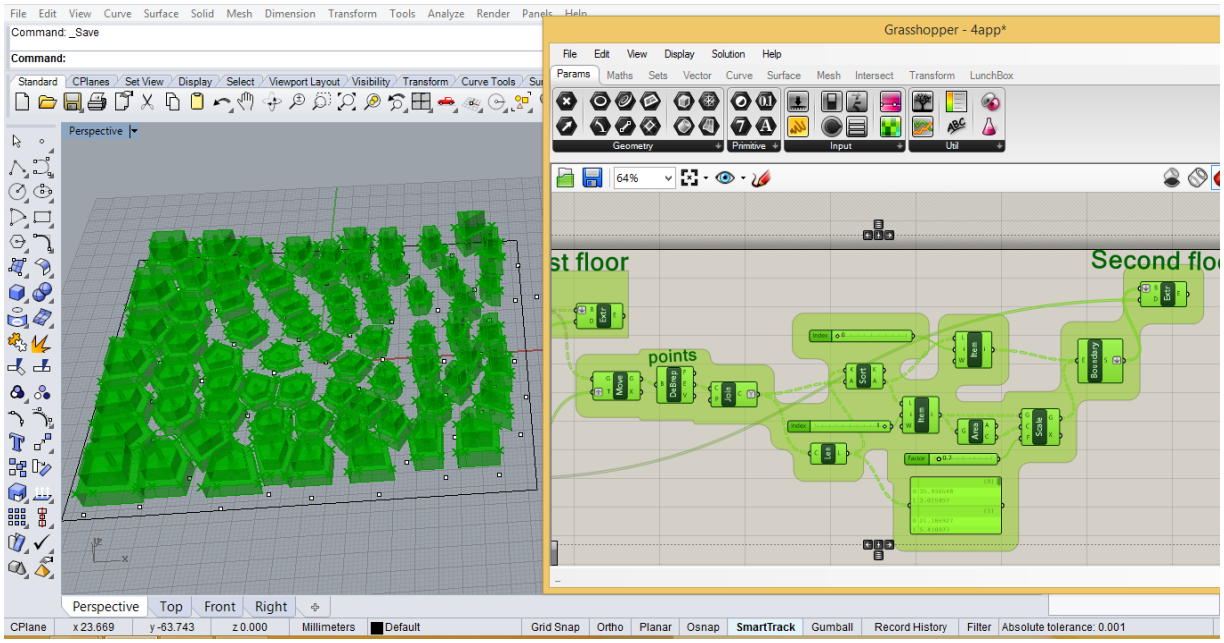

Fig. 6: building with internal courtyard.

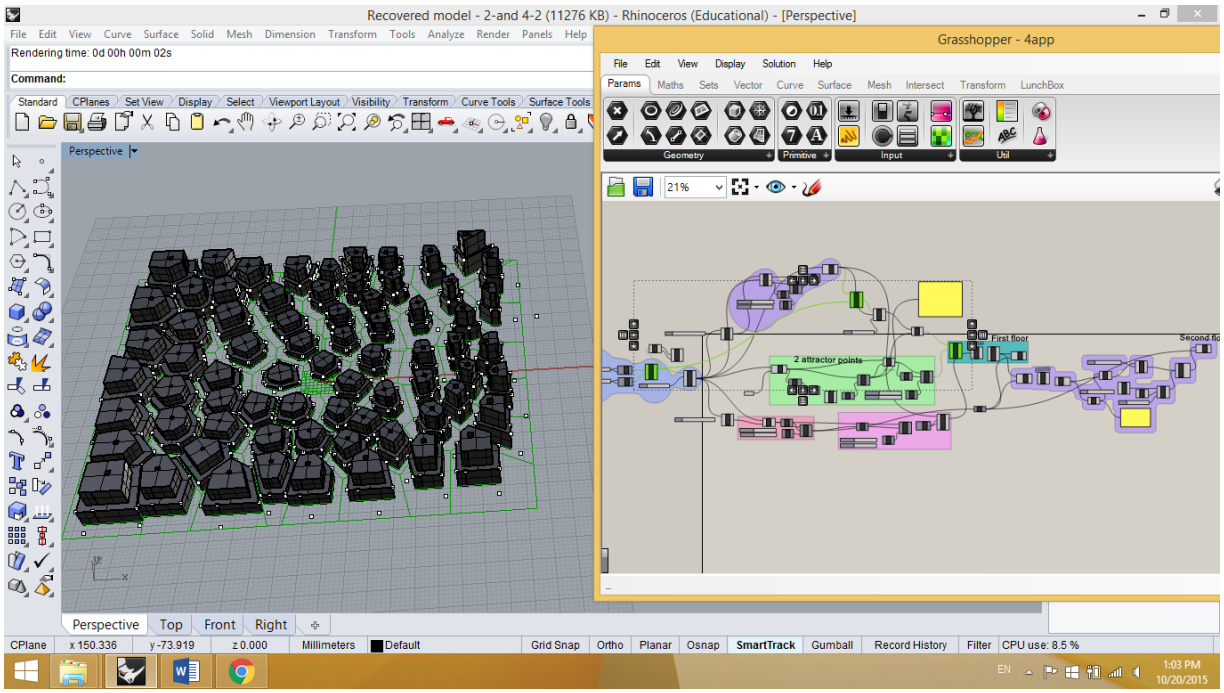

Fig. 7: generating urban fabric with fixed relations.

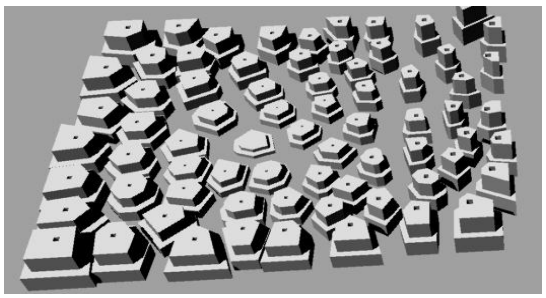

Fig. 8: rendered blocks.

4. Conclusion

This paper tries to deduce new urban design processes that enhance the quality of life using parametric design tools, and tries to solve problems facing developed urban areas and new developments by implementing new computational design techniques.

While parametric urban modeling was created to achieve particular interdependencies and proportion, this parametric urban models is very suitable to the nature of urban life which is complicated due to the human being identity. Parametrics play an important role in the project not only in terms of creating a system responsive to the context conditions but also in its ability to produce a diversified result. The final master plan proposal is an iteration that follows up from the prior versions and is certainly more developed than the earlier ones. The system developed here therefore has the potential and the ability to evolve continuously. “Figure” 8

5. Recommendations

- Generating digital design modelling with fixed relashionships could be applied to any different site condition with responding values to the qualities of urban life. This model helps the designer to enhance the design process with multiple design solutions and different parameters variations.
- ‘Generative Algorithms’ are a series of design experiments which are aimed to develop concepts, theories, tools and techniques for algorithmic design. The aim is to share the knowledge of algorithmic design with all designers and practitioners who are active in this field.
- The adaptability of the system is its greatest strength, based on its parametric setup. However the designer can strengthen this setup using more informative input and analyze it efficiently for human wellbeing or in Ecotect for environmental effectiveness.
- Findings are recognized and used in a timely manner by those formulating urban policy, including urban designers, urban planners and elected officials. For many engaged in such research, a motivating factor is the desire to generate data that would inform policy and environmental design decisions so as to optimize the QOL experience of urban design.

6. References

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