Generative Urban Parks: A Parametric Analysis & Production Methodology & Generative Modular Pattern Creation as Parks

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As a fast-developing field of computational architecture, generative design is an important bridging tool for architectural and urban design to computational opportunities after the digital revolution. Enhancing both analysis regarding the site & context and form finding processes in urban architectural design projects, generative design systematizes the variation creation within its system in an easily manageable parameter dependent optimization. One of the major contribution of generative design is, that it helps testing the multiple options as the computer generated complex alternatives, therefore, the best choice among the most suitable many ones is sustained by the capability of computation in the age of digitalization. Taking the automation advantage of generative design, this study aims to discover how a system of generative design can be developed and utilized to enhance the greenery design in urban spaces in the form of urban parks. The methodology proposes a modular creation to be composed with garden aesthetics strategies and a random urban park generation system to be created via Grasshopper parametric modeling tool. The end products are going to be tested on a site as an urban square area and an aesthetics evaluation of the computerized design with a perspective of urban greenery design is going to be made. All things considered, this research designs an integrated system of an urban park design generation through computational automation in order to further revolutionize the architectural design process of urban areas.

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1. Introduction to Urban Parks & Environmental Design

The urban built environment so far developed by creating a huge negative impact on the life of other species and the natural environments are disturbed by the human-made artificial building strategies. A shift in the perspective to the built environments has been taking place as the people become more aware of the fact that anthropocentrism routed them to superiorize their own species to the others and to disturb the atmosphere and the earth by removing nature distinctively from the urban areas. Antoine Picon's words support the idea as: "an examination of what environmental concerns and climate change are currently doing to architecture might actually help throw some light on the complex question of the real nature of the digital revolution in architecture, beyond the successive crazes of digital avant gardes" (Picon, 2020, p. 121.) Therefore, present day urban and architectural development involve not only design for homo sapiens but also for other species and for bringing back the natural environment the cities previously lost.

Urban parks as greenery designs are the tool for the cities to sustain the cycle of water and air, and smart cities are regarded with how much urban park area can a city provide for its citizens as an important aspect of green and net zero cities. Currently New York city is known as the most urban greenery providing city to its citizens, and other cities aim to develop their ratio so as to create clean air, walkability, public health and aesthetically enhanced urban development. Plus, urban parks can be designed with Animal -Aided Design Concept (Weiser, 2017), through which the design is made by the involvement of selected species' lifecycle implemented in the urban park areas to diversify the natural environment with many species. In light of all of the above-mentioned benefits of the sustainable urban greenery development, urban park designs create the potential solution to the wrong urban development previously done under the effect of anthropocentric consideration of the cities, to develop healthier for as many species as can be involved.

2. Greenery Design, Computational Transformation Strategies: Vision Statement

When urban parks are considered as a cluster of individual units, the elements combining to create urban parks can be regarded as single units of a system to be developed. To further explain, the trees, bushes, short plants, flowers, water elements, urban furniture elements and so on are the pieces that stand out together organically to form up the urban park. Therefore, this perspective from whole to unit, creates the potential to develop a computational generation of urban park design by introducing the system with urban park elements as individual units. The unification of the single units is suitable to be developed with random combinations of the individual pieces to come together to form up the urban park in a defined area. The randomness as a choice is advantageous and disadvantageous in some ways as it has the benefit of producing many alternative designs to pick up the most desired result at the end, but the randomness should be restricted with design strategies regarding the urban park design not to involve infinitely many non-suitable solutions from the randomness feed.

In order for the generation plan and strategy to work in the most suitable way, a computational site-specific analysis should be carried out, so that a related species selection can be done. When a climatic documentation is derived computationally, its analysis would route the designer of the system to make better fitting choices for the elements definition. The Ladybug add-on to Grasshopper Plug-in in Rhinoceros 3d modeling software can document climate data into visual graphs, so that the data of the selected site can be implemented into the Ladybug code and a climate chart and be derived as the initial step of the investigation. Therefore, analysis, design and creation as three steps has the potential to computationally proceed as a workflow to create urban park design alternatives.

The vision statement behind such a computational work trial is that after the second digital turn as Mario Carpo defines it, the computational developments and human life enhancement are developing each other in an accelerating way. Such contribution and cooperation of digitalization with ecology awareness can become a generative system regarding the both fields as a prototypical small scale design. Plus, the simple random generation can be developed further for future studies and can become a machine learning and artificial intelligence work to start and finalize the whole work from analysis to urban park generation, so as to revolutionize urban park design with ecological considerations, smart city development and computational architecture.

3. Methodology

The project is designed upon three major steps of computational work as the site analysis regarding the climatic conditions, the module design of urban park needs according to the species selection procedure and the urban park developing system generation. The digital analysis of the climatic conditions is the keystone of how to decide on the species of trees that are suitable to undergo an optimal life cycle within the site and to be able to diversify both the ecological environment as the urban greenery and the modular computational units. When the first two phases are completed, the unit modules become prepared to be introduced into the system, so that alternative garden generations can be made by the Grasshopper code with a system of designed and restricted randomness according to the expectations from the urban garden. The step by step instructions of the complete methodology is drafted below as:

Phase 1: Site Analysis

Tool: Rhinoceros - Grasshopper - Ladybug add-on

Aim: to create a digital documentation and understanding of the climatic context of the site to make appropriate species selection

Process:

Using the website of ladybug data map, the weather data of Istanbul is downloaded in the epw format.

The data is linked to the file path and related commands of ladybug to form up the graph of annual weather data based on the radiation per square area. The code screen is shared below as:

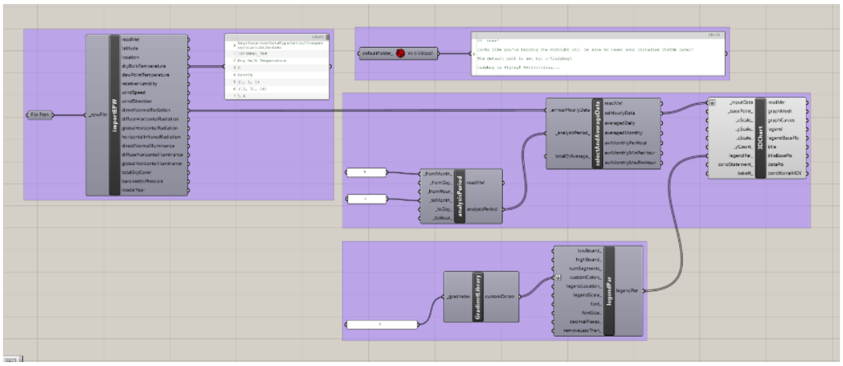


Figure 1: Ladybug Climate Graph Creation Code on Grasshopper Interface

The resulting graph is baked and the graph becomes the tool to analyze and understand the climate condition in Istanbul to proceed with species selection process before generative system design.

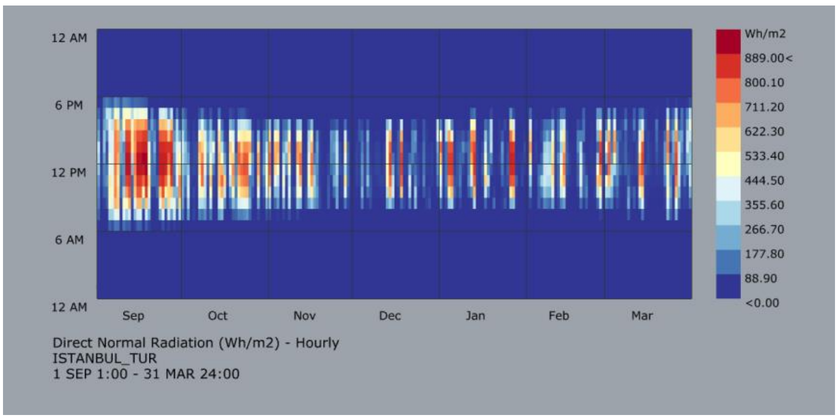


Figure 2: Ladybug Climate Graph Outcome

Phase 2: Module Design

Tool: Rhinoceros

Aim: to prepare the units of the assemblage of the urban park design to be introduced into the grasshopper as the elements to be placed in the defined surface

Process:

1m*1m base modules are prepared to be modeled with the urban park elements previously defined as trees, bushes, plants, flowers, urban furniture and water elements.

The selected greenery species and park elements are downloaded as 3d object models by the website: Turbosquid to resemble the selection visually on the model.
The downloaded 3D mesh models are scaled and a mesh reduction is made by 80% to each element in order for the system to work more optimized for the future steps in grasshopper software.
Selected species of trees are placed separately on modules and further greened by the support of bush and flowers.
A 3m*3m module (same as 9 united 1m*1m modules) is designed with the water element as a garden pool.
The bank as urban furniture and lighting element for dark hours' use is placed on a 1m*1m module.
Selected species of trees are located in separate modules.

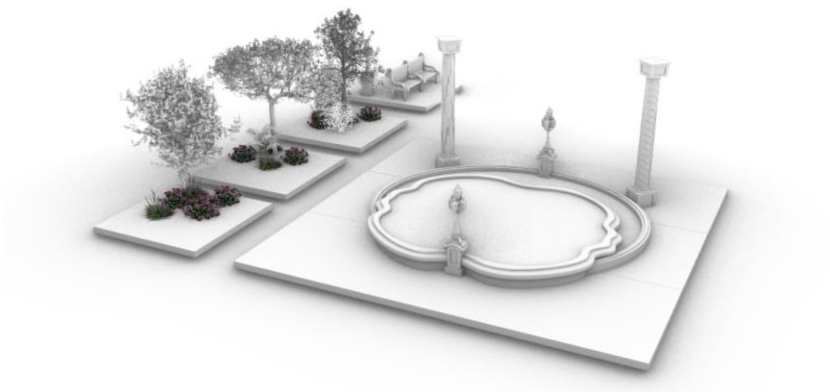


Figure 3: Module Design Phase Product

Phase 3: Urban Park Generation

Tool: Rhinoceros - Grasshopper
Aim: to create a system producing high amounts of alternatives for an urban park design to provide the rule setup regarding the basic desired elements layout on a gridal base.
Process:
A Grid of 15m*15m is formed out of 1m*1m unit rectangles as the base of the park
All modules are introduced in grasshopper as separate multiple geometries
The system is coded to make random placings on the grid by the modules

The randomness is restricted for the better outcomes of desired urban park alternatives

The system can only place 1 water element on the grid

4 Urban furniture module should exist near the water element

Side modules should consist of only tree

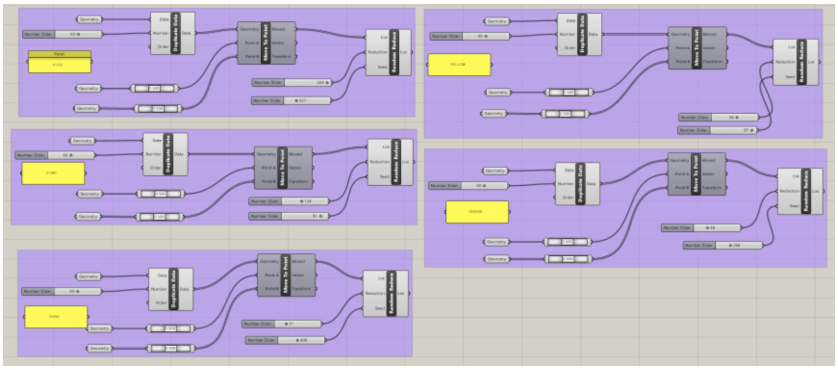


Figure 4: Urban Garden Generation Code on Grasshopper Interface

3.1. Sample Experimentation

All three phases of the methodology of this study is developed on a case in Istanbul, Sarıyer District Data in epw format downloaded on Ladybug's climate data supply. When the climate chart is formed the tree species selection is made according to the chart and the selected trees for the case are Oak, Stone-pine and Chestnut trees. When the design phase is completed the modules are color-coded in order not to directly use the high-poly tree models to increase the computer work efficiency and speed. The color-coded modules are shown by **Figure 5**.

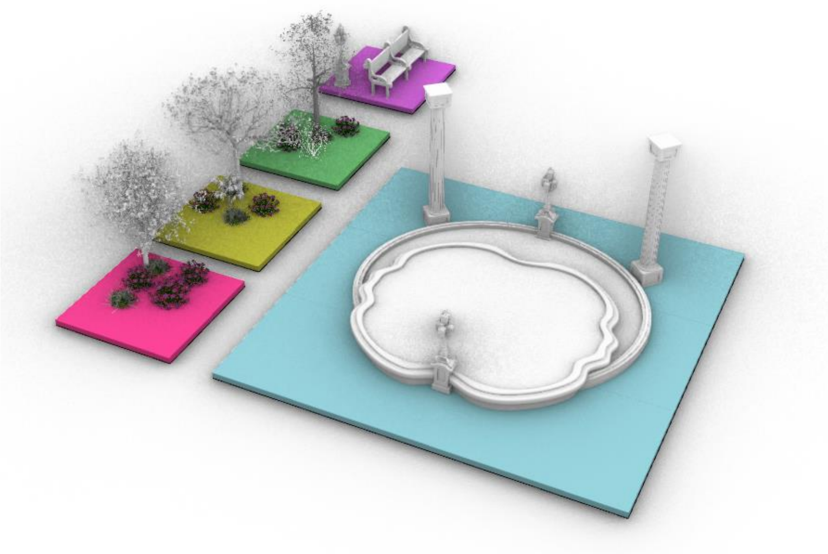


Figure 5: Color-coded Module Designs

Three alternative outcomes from the urban park generation code on Grasshopper software are produced as sample urban parks. The color coded alternatives are shown below by **Figure 6**.

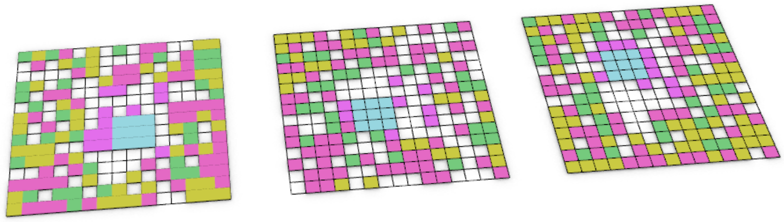
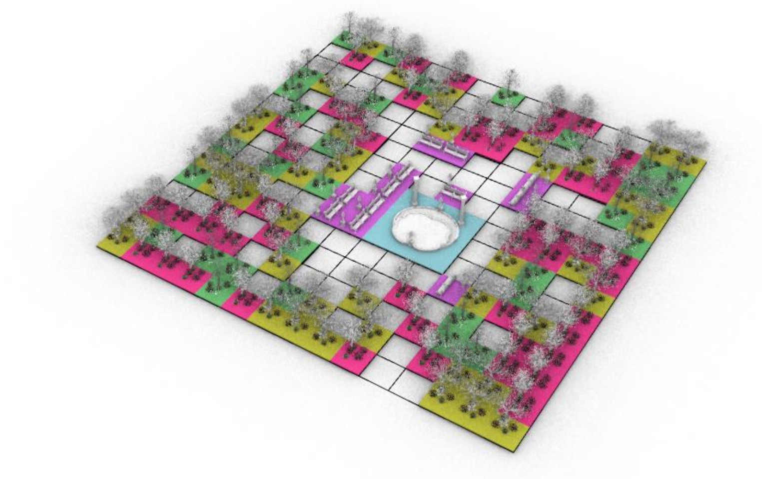


Figure 6: Three Alternatives Generated by the System

The color-codes are matched with the module designs at the end to form up the urban park design visually and the final outcome of an example automatically generated urban park is illustrated by **Figure 7**.



The system and the random creation with restrictions and rules are all worked well and simple yet and optimized automation system is achieved at the end of the methodological work. This study concluded that computational architecture and urban development is possible with whole to unit approach and modular designs has the ability to unite with each other in the desired way to create fast and many in number alternatives as a future promising system to be developed further to make even more complex urban greenery design to implement more layers such as mobility aspect, animal-aided design target species' lifecycle and many and more ecologically sustainable enhancements for the built environment.

4. Suggestions for Further Investigations

This study as a prototypical small scale urban park generation trial has provided the opportunity to develop a progressive computational design in an organization starting from computational climatic analysis to deliver alternative computer generated urban park elements assemblages on a defined area. Therefore, the number of species, the type of urban elements and furniture, and type of water bodies as the dependent variables can be increased to get more diverse outcomes from the system for the further investigations. Plus, to extend this minimal level generation work, the manually arranged or designed parts of this methodology can be developed to be computationally done. To exemplify, the tree species selection procedure has the potential to be done by artificial intelligence when trained about how to get the climatic input from the ladybug analysis result, and make selection among the climate specific tree data it is inserted. As an enhancement to the visuality of the project, the models of the elements like trees could be modeled by the owner of the study instead of regulating the ready online models to be able to develop a visually unique style specific to this exploration of urban park generation models.

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