

Information Urbanism

Parametric urbanism in junction with GIS data processing & fabrication

Ming Tang¹ and Jonathon Anderson²

¹University of Cincinnati

²University Of North Carolina Greensboro

ABSTRACT:

Parametric Urbanism, pioneered by Zaha Hadid & Patrik Schumacher Architects with support coming from advanced computational technology, has been the interest of architects and urban designers in recent years. This new design thinking has been used in projects ranging from large scale urban development to building façade/surface design. However, the integration of demographics, cultural, and human factors into this computer controlled equation has so far been neglected. The gap between a simplified condition in the parametric design process and the actual complex urban context in the real world raises the questions of the parametric urbanism manifesto. .

The authors present a study investigating the information processing of Parametric Urbanism and describe a new procedure coined -*Information Urbanism*. Unlike parametric urbanism, *Information Urbanism* considers cultural cues and demographics as input parameters. *Information urbanism* is defined as a hybrid method which seeks logical urban forms and analyzes its' importance through urban design education. The authors extended this method by exploring, collecting, analyzing, and visualizing urban information and physically representing the information through digital fabrication technology.

The research presented within this paper is intended to realize the potential of quantifying demographic, social, and cultural data into a parametric equation. In these experiments, the integration of non-geometrical parameters within the form seeking and fabrication process resulted in a series of conceptual make-ups of city. The models were developed by manipulating zoning, transportation network, city block and various building types. Ultimately, *Information Urbanism* looks to build upon the strengths pre-defined in the Parametric Urbanism method and capture the benefits of Geographic Information System (GIS) by seamlessly integrating vital geospatial components in the equation and altering the way people explore the possible design solutions in order to generate the ideal urban forms.

KEYWORDS: Parametric Urbanism, Geographic Information Model, Digital Fabrication

INTRODUCTION

Information Urbanism is a collaborative research project focusing on the integration of Geographic Information System with the theory of parametric urbanism where the emphasis is placed on data collection, pattern analysis, visualization, parametric spatial modeling, and physical representation. This exploration of spatial diagramming, through digital modeling and fabrication, showcases how the urban phenomenon and its geospatial pattern can be interpolated into parametrically controlled forms which can later be translated into design solutions. Patrick Schumacher describes how the parametric thinking “confronts both, the remaining vestiges of Modernism’s monotony, and the cacophony of the urban chaos that has sprung up in the wake of Modernism’s demise, with a complex, variegated order inspired by the self-organizing processes of nature” (Schumacher 2010). This design ideology places emphasis on variation and correlation rather than a linear pipeline that does not allow for the exchange of information. The design solution, either a piece of furniture or an urban form, is explored as a network of parameters. “Thus everything is potentially made to network and resonate with everything else” (Schumacher 2010). The supporting theories emphasize the activity of event parameters within the urban life process. Parametric Urbanism echoes morphogenetic urbanism, swarm urbanism, and rhizomatic urbanism. However, it has a very distinct integration with computation technology supported by advanced 3D programs and computer scripting.

This method has been demonstrated by Zaha Hadid & Patrik Schumacher Architects in several large scale urban design project such as Soho China, Beijing, Stone Towers, New Cairo and Expo City, Cairo. By placing parameters on the social event and including contextual information the key function of the parametric script is used as a form seeking method and ultimately generates the final solution without any reference to contextual or demographic information. Although parametric urbanism has been promoted by the practice of Zaha Hadid & Patrik Schumacher Architects and has been taught in Architecture Association (AA) for several years, the integration of demographics, cultural and human factors into this computer controlled equation (virtually molded with points, lines, planes, and volumes) has not been fully discussed under the umbrella of parametric design. The way to generate urban forms that contain layers of information still remains as a mysterious process. As a result, the audience was left under the impression that ideological manifesto of parametric urbanism distinguished Zaha's architectural style. Therefore, we are left with designers not knowing how to model or simulate the form from the parametric drivers, or more importantly how to interpolate the information which is presented. The gap between a simplified condition in the parametric design process and the actual complex urban system in the real world raises the curiosity and questions the design process of parametric urbanism in practice.

The authors recognize the philosophical significance of parametric urbanism, as well as its lacking of technological explanations of information processing. Our research goal focuses on the process of parameterization of geospatial information into 2D patterns, 3D forms, and experiments various methods to represent the information physically with CAD/CAM tools.

I. INFORMATION PROCESSING FABRICATION

The interaction between human activity and the urban form is essential in understanding a generative city design. As Neil Leach described in Swarm-urbanism, "it as though the city is 'formed' by registering the impulses of human occupation, much as the sheets on our beds, for example, record the movements of our bodies through the night. But so, too, the city constrains the possibilities of human movement and demographics through its very physicality. There is, therefore, in Deleuzian terms, a form of reciprocal presupposition between city and occupants. The city modifies its occupants, no less than the occupants modify the city. Over time the fabric of the city evolves through interaction with its inhabitants." (Leach, 2010).

The first step of our study is the collection and interpolation of demographic information from Geographic Information System (GIS) application. GIS acts as the data collector of "impulse of human occupation" (Leach, 2010). To explore this essential component of information urbanism, the authors investigated the process of using parametric modeling as a new method to convert non-geometric information from GIS databases into a meaningful 3D diagrams. With projects produced in urban design courses, and independent study taught in 2010, the authors and a group of students presented a study investigating the new workflow of using GIS and fabrication within the urban design field and described a procedure for exploring, collecting, analyzing, and 3D representing of urban information from Census data by diagrammatic digital models and fabricated physical models. The research team manipulated the quantifiable GIS data of two case studies, Cincinnati, Ohio and Savannah, Georgia by computing political, social, and economic data into the 3D topographic representation.

In this process, various GIS data themes such as zoning, transportation network, city block and various building types were visualized as a series of virtual models, each of which exclusively responded to its GIS information input. These virtual models record the continuous process of urban form morphing, mutating impacted by the various force/field simultaneously. These models are rendered as a storyboard to simulate the data processing and its interaction within a neutral urban grid. As GIS data imprints the urban form, the authors considered these digital representation models as ambiguous urban diagrams. Here the factor of scale was left absent from discussion and analysis as it allowed the urban fabric to manifest itself based on the human input and reason. The outcome either be diagram or photorealistic renderings, can change people's perception of existing urban landscape and inspire designers to understand the urban form in a new perspective.

The layers of information presented in the digital portion of this research were then explored by the physical fabrication of architectural or urban artifacts. By digitally fabricating the forms and diagrams we were able to experience the urban information through the physical act of making and allowed another opportunity to design the outcome. The integration of non-geometrical parameters such as age, gender, race, poverty level, education level, employment status, family income, and method to travel, were processed and influenced the 3D form. This process was explored as datasets that could be fabricated through a variety of techniques. Ultimately, the results would be read as a physical diagram that revealed information about the series of conceptual make-ups of urban topography. These forms were fabricated by laser cutting and CNC milling various materials. The importance of realizing these conceptual models in the physical world was explored as a way to directly correlate various fabrication techniques such as layering, tessellation and contouring, to the urban landscape properties such as zoning, building massing and grid pattern in a diagrammatic way. Still, through the fabrication process the artifacts maintained the ambiguity and flexibility for designers to translate these physical artifacts into their own interpolations.

2.EXPLORATION OF THE WORKING PROCESS

2.1. STEP ONE. INFORMATION MODELING

This process first started with information from the local census report and GIS data set. Once the geospatial information was compiled, it was then filtered and manually selected based on its significance in term of spatial pattern recognition. In our experiments, data of Cincinnati, Ohio and Savannah, Georgia from the U.S. Census Bureau was used to develop a demographic study on the geospatial information. The information is visualized as thematic maps with gradient color to represent the quantifiable value from the data base. The color value of each pixel in the GIS thematic map is then been used as a parameter (range 0-256) to drive a rule based 3D modeling. A homogeneous grid was set up as the representation of initial global structure and then later deformed by the local actions, like the effect of “local action on global structure” defined by Batty. (Batty. 2007) We use both customized MEL and Grasshopper scripts, as well as advanced modeling tools such as Maya and Rhino to construct the 3D information model from these 2D parameters. Information modeling comprises of infinite possibilities with controllable variables within a parametric framework. These variables are then run through a series of alterations to morph into abstract urban forms.

For instance, we created White, Black, Hispanic, and Asian population thematic map of Cincinnati and studied the pattern overlaid with the railroad system to explore their correlations. By taking this 2D information into Photoshop to manipulate the color value through selected filters, we could

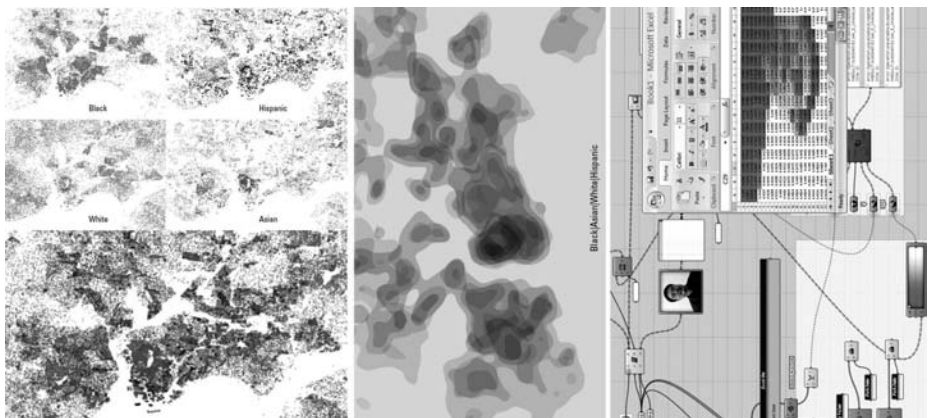


Figure 1: GIS thematic maps allowed us to extract geospatial data and convert it into raster images. By isolating major demographics, students were able to export these raster images into Excel, Grasshopper, Photoshop to fine tune the data in a way that the polygon mesh in 3D program could interact with the images¹

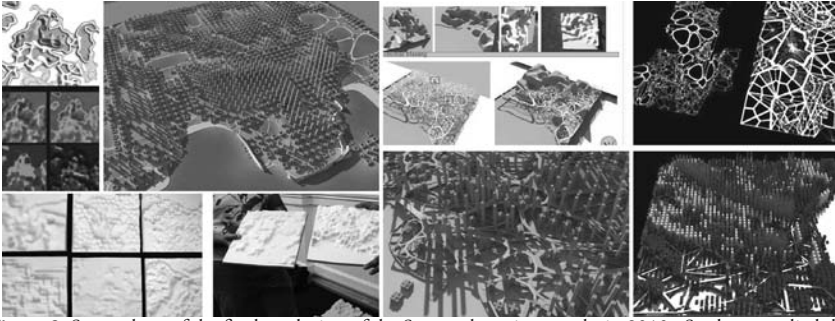


Figure 2: Screenshots of the final resolution of the Savannah project taught in 2010. Students applied the image-based information to the 3D surfaces and then applying the weave pattern script. ¹

mix, eliminate, move and separate our findings. We also extracted the information with image sampling processes in a grasshopper script and then streamed the information to a Excel sheet for further calculations (Figure 1). A new method to convert image-based data into a tessellated 3D polygonal mesh was developed in Maya. These data-driven poly shapes allowed for automatic surface tessellation, and the generation of the mutating areas within a generic grid system (Figure 2).

As a result of the digital representation, the information presented in the 2D maps and 3D models empowered one to draw their own conclusions and develop several intriguing design schemes. The authors view these generated diagrams as a scale-less drawing. It is only when these diagrams are taken by an architect or urban designer that the issue of scale is represented. The layers of information such as streets, pedestrian walkways, and building mass can all be directly extracted from the diagrams. As a result, we have an urban form that is influenced and justified by information that is processed and driven by human and computer interaction.

2.2.STEP TWO: FABRICATION

With the newly generated data the creation of physical models through CNC milling and laser cutting was relatively simple. The filtered data was taken into Rhino and Maya program which allowed us to manipulate and control the spatial pattern and generate the appropriate file for digital fabrication. As a result we translated the abstract information into cutting patterns, tool paths, and controlling information of the energy and speed of laser beam. Here, a numeric GIS dataset is taken as input and generates the scripts for Laser cutting and CNC milling. These artifacts were informed by the none-geometric GIS data processing and not designed arbitrarily by the researchers and fabricators. The authors' only influence on the computer generated diagrams was to manipulate the information into 2D patterns or 3D tool path that would highlight various instances. While doing this process, the authors had to take into account material selection, tagging system, fabrication technique, and machine processes. (Figure 3).

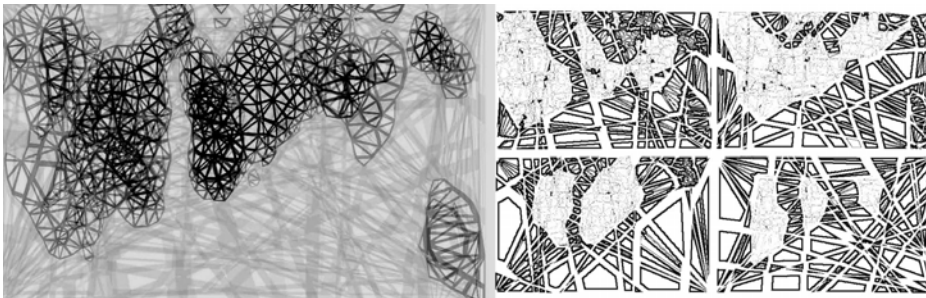


Figure 3. In a course taught in 2010. Students used various maps to study the relation of the demographics and transportation system in Cincinnati to generate vector drawings needed for laser cutting. ²

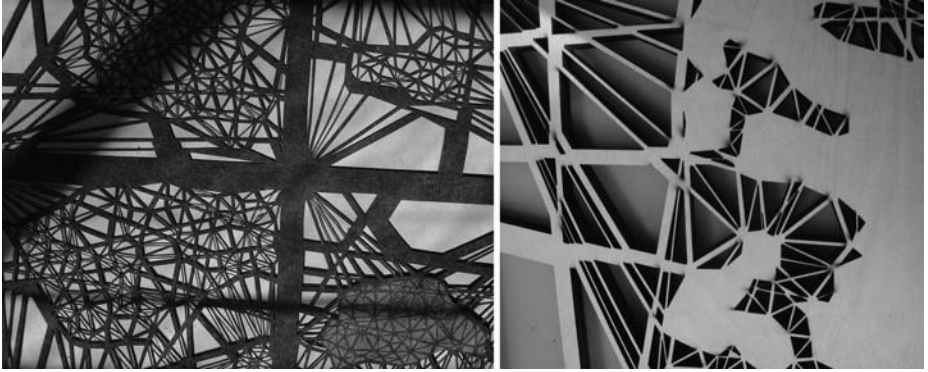


Figure 4: Left: Using synthetic felt with a fill layer. Right: GIS driven pattern cut on 1/2" Birch plywood. ³

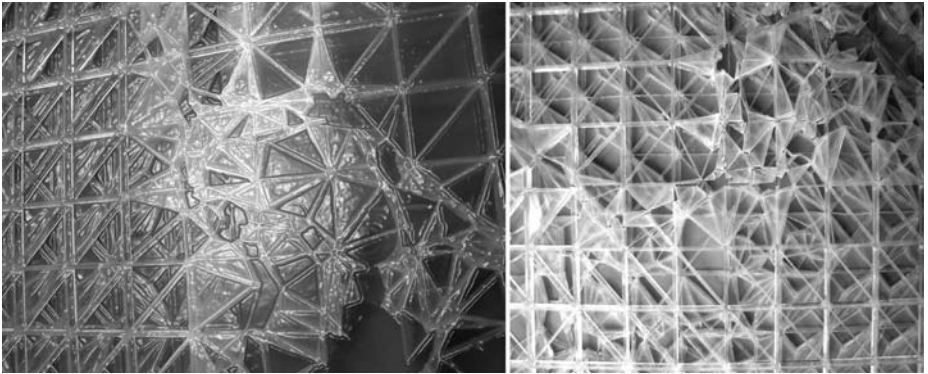


Figure 5: Acrylic panels produced based on Cincinnati transportation data. ⁴

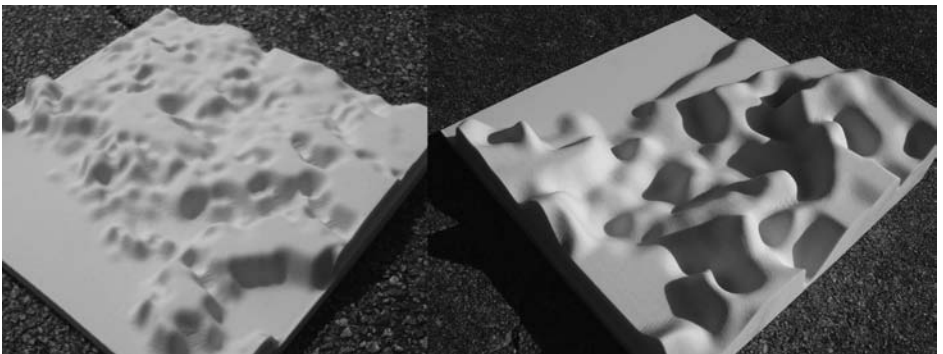


Figure 6. After transferring family income data into a 3D surface, the form was sent out to Power Mill and then milled with three axes CNC. ⁵

Fabricating, assembling, and interacting with a 3D physical model are the unique experiences that designers will never be able to achieve by viewing an abstract GIS map. The physical model became a representation of the dynamic relationship among GIS data sets. The objective was to physically realizing selected iteration(s) rather than exercising the fabrication technique. Multiple laser cut boards were overlaid and produced composed layering effects just like GIS program. The cut off material can be analyzed and even reused to build a new model that highlights inversed relationships. The marriage between GIS and fabrication technologies stimulates a different mindset and design thinking process. The dimensional and physical model becomes an object that not only represents the combination of various GIS data sets, but also displays the unseen spatial pattern and sparked the unique design solutions (Figure 6).

This fabrication process is not just a three dimensional realization of the digital forms because it does not focus on the craftsmanship or prototyping as the conventional fabrication does. It is through the digitally fabricated artifacts that we begin to observe, touch, and interact with the GIS data set and examine their correlations physically. The researchers view the artifacts as diagrammatic forms related with building facades, street layouts, and master plans with zoned clusters. Because of the parametric control of the entire workflow, the researchers are able to generate many physical iterations in a relatively short period of time. It is the interplay between the digital and the physical that this idea of *information urbanism* develops possibilities that are empowering and justified.

3.SWARM CITY

Swarm City is one of our experiments exploring how to use the diagrammatic geo-spatial data to automatically construct a highly detailed urban model for a video game. The entire city was generated out of a network of parameters. The goal is to simulate the possible form of urban fabric, a “wet grid” described by Frei Otto, a diagram city, which grows from a complex social pattern, rather than following an imposing neutral gridiron pattern. The complex urban fabric relies on how individual building’s parameters, such as dimension, FAR, roof slop, window to wall ratio, respond to the landscape features such as contour, vegetation, and view shed. A tool named “City Generator” has been developed based on the Generic Evolution computation using procedural model and GIS map. In the first phase, *City Generator* is used to “breed” selected architectural models across several generations. In the second phase, *City Generator* uses 2D maps to generate 3D spatial occupancy (SO) model. These 2D maps contain GIS data, which reflect zoning, population, transportation, and other spatial information. In the final phase, each voxel in the SO model of Phase II is substituted by a detailed procedural building model survived in Phase I. The substitution rule is defined by the designer according to design criteria. For instance, a view-shed map is created based on GIS digital elevation model (DEM) to control the placement of building’s orientation. A family income map is used to control the placement of particular building style, height and façade feature. A population density map is used to control the placement of community centers and public space. A DEM map is generated to move all buildings up and down following the contour lines. These maps contain information to parametrically control thousands of building typology to morph gradually. “Expressions are altered and various spatial arrangements are produced as the information input is switched.” (Tang, 2007) Here, the concept of information urbanism provides the engine to auto-construct the city based on simple rules and logics (Figure 7).

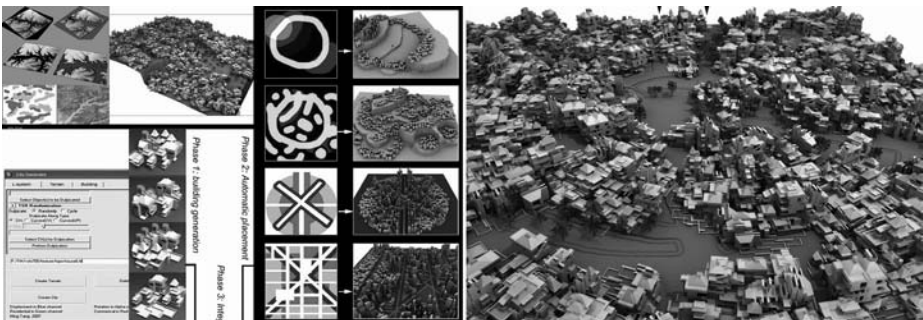


Figure 7. Swarm City Project. GIS driven parametric urban model.

4.CONCLUSION

Through the research and teaching, our intension is to use the demographical, social spatial data as forces to control both urban layouts and individual building's parameter. Here, morphological output variables can be programmed to respond to environmental input parameters. This interactive relationship can be even realized in a much smaller scale like glazing panels and shading devices, "As the system of shading elements wraps around the façade the spacing, shape and orientation of the individual elements gradually transform and adapt to the specific exposure conditions of their respective location on the façade. The result is a gradient, continuously changing façade pattern that optimizes sun-protection relative to light intake for each point on the façade" (Schumacher 2010). As the parametrisation can be applied in all the design scales, from micro to macro, large scale *information urbanism* can be used to control the detailed building style as well.

We believe the geospatial database can provide a rich resource to optimize urban forms with respect to ecological performance criteria. The demographic, traffic, economic data from GIS provides the trace of activity and event parameters of the urban life process. As Schumacher described in the *parametric city*, "parametricist continuation is always possible in myriad, unpredictable, and qualitatively diverse ways, but it is never random" (Schumacher, 2010). Different from traditional urban design process, the *information urbanism* provides us a range of abstracted urban diagram, rather than a particular design solution. In another word, the outcome of *information urbanism* is the consistently morphing forms driven by the changing relationship of information, which can be interpolated into physical landscape features. As Kokkugia team has claimed 'Our urban design methodology does not seek to find a single optimum solution but rather a dynamically stable state that feeds off the instabilities of the relations that comprise it.' (Leach 2010)

The value of parameterize urban information, realize the 3D form, either conceptual or diagrammatic, through digital computation and fabrication became a valuable teaching and research method in architectural and urban design field. It created an interesting notion to the parametric urbanism practice and further exploited the idea that design practice begins with the information. This ongoing research is now focusing on how to organize and share the open source script to the research community and continue the collective study to build a bridge between GIS database and parametric urbanism theories.

REFERENCES

- Neil Leach, *Swarm Urbanism*. Architectural Design. Wiley. 2009.
- Patrik Schumacher. *Zaha Hadid – Recent Projects*, A.D.A. Edita, Tokyo 2010
- Peter Trummer. Morphogenetic Urbanism. Digital Cities. Neil Leach. *Architectural Design*. Wiley. 2009.
- Michael Batty. *Cities and Complexity, Understanding Cities with Cellular Automata, Agent-Based Models, and Fractals*. The MIT Press. 2007.
- Ming Tang. City Generator: GIS driven genetic evolution in urban simulation. *ACSA 2007 Conference proceeding*. Austin, TX. 2007.

ENDNOTES

- ¹Projects from Independent study. Fall 2010. Students: Enrique Sanchez. University of Cincinnati
- ¹Projects from ELDS 306, Summer 2010. Students: Johnson, Natalie; Lueders, William.; Alamri, Abdulghadir; Bakarman, Mohammed; Bindajam, Ahmed; Davis, Jarrett; Shareef, Muhammad; Su, Yang; Warren, Ryan. Savannah College of Art and Design.
- ²Projects from Independent study. Fall 2010. Students: Enrique Sanchez. University of Cincinnati
- ³Projects from Independent study. Fall 2010. Students: Steve Stidham. University of Cincinnati
- ⁴Projects from Independent study. Fall 2010. Students: Michael Zhao. University of Cincinnati
- ⁵Projects from ELDS 306, Summer 2010. Students: Johnson, Natalie; Lueders, William.; Alamri, Abdulghadir; Bakarman, Mohammed; Bindajam, Ahmed; Davis, Jarrett; Shareef, Muhammad; Su, Yang; Warren, Ryan. Savannah College of Art and Design.