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Pitts, Gregory, Farley, Holly and Datta, Sambit 2013, Research in practice : an exercise in generative urban massing, in *CAADRIA 2013 : Open systems : Proceedings of the Association of Computer-Aided Architectural Design Research in Asia 2013 international conference*, Association for Computer-Aided Architectural Design Research in Asia, Hong Kong, China, pp. 685-694.

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RESEARCH IN PRACTICE

An exercise in generative urban massing

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Abstract. The following paper explores practice based research as a means of identifying issues within current urban design methods. It considers the application of parametric systems as a means of addressing these issues. These systems are developed and tested across both Australian and international urban design projects within Grimshaw Architects. A methodology is proposed for the development and application of these parametric tools across multiple scales of design resolution. It reports on the application of a set of parametric urban scale massing tools in real world design projects. This exploration is carried out in distinct phases of design defined by the scale of resolution. The phasing allows for discrete problems to be addressed more effectively at different stages of the design process while still encouraging a seamless, bi directional workflow through a digital master model.

Keywords. Computational design methodology; parametric design; city modelling.

1. Introduction

Computational Design Methodologies play a variety of roles in the analysis, design and construction of buildings. Computational and parametric design methods are no longer foreign to the processes of design in practice. In particular, recent developments in parametric design have allowed for a greater expression of complex ideas and design. These programs have defined a new methodology in practice and research in the field of non-standard architecture (Stavric and Marina, 2011). Despite

this growing trend, design outcomes continue to suffer from serialisation, standardisation and a proclivity towards geometric primacy (Vincent et al., 2010). This highlights the need to reassess how we employ emergent technologies in architectural practice and whether it can be seamlessly integrated into existing design methods.

For example, there is rapidly growing research in the application of parametric systems to the complexities of urban design. Unfortunately very little of this research has been resolved in terms of a tested and replicable design methodology that quantifies cause and effect of parametric application within our current design practice (Schnabel and Karakiewicz, 2007; Tang and Anderson, 2011). The 'black box' of technological toolkits are unattainable for the majority of design practitioners. Technologies and, contemporary problems in design practice need to be coupled through "embedded research" in practice (Maher et al., 2006).

This paper explores embedded research as a mutually beneficial knowledge sharing exercise that aims to bridge the gap between the worlds of academic research and architectural practice. It reports on the development and application of a set of parametric urban scale massing tools across a series of real world design projects. This exploration is carried out in a series of distinct phases which have been defined by the scale of design resolution. The process demonstrated in the following case studies adhere to a set of general rules for parametrically generated urban design.

- Models are limited to indicative massing diagrams in both 2 and 3 dimensions.
- Information has to be universally understood between the required digital systems as well as the human stakeholders and designers at any point in the process. This limits data loss and misinterpretation as well as reworking of digital data for human consumption.
- Any system has to be capable of both scaled intervention and scale less automation. Although bi directional parametric models can be considered scale less, the human process of design and problem solving still requires the defragmentation of scale and complexity.

2. Benefits of Parametric City Modelling

The inadequacy of traditional urban design and planning techniques and standards is widely recognised as insufficient for creating successful urban developments (Lowry, 1965; Ingersoll, 2006; Cuthbert, 2007). The potential for unifying current technological capabilities and the practice methods of urban designers is one way to address this problem. Parametrically governed systems have the capacity to compute large sets of complex data and generate outcomes from pre-defined inputs and control parameters. This sets up a recognised problem in urban design complexity with an accessible system that has the potential to address the shortfalls in traditional design approaches. This complexity and multiplicity of scale can benefit from a set

of programming and visualisation interfaces designed to manage large data sets and optimise physical forms as determined by the designer (Stavric and Marina, 2011).

The case studies presented in this paper explore these interface issues through the following research questions. Firstly, how can urban design aims and requirements (parameters) be communicated successfully for use and utilisation in parametric programs? Secondly, how can this language be reduced in complexity to be used as a problem-solving medium while still retaining an inherent and explicit understanding of the embedded complexities?

3. Massing and Density Modelling as a Method of Diagramming

Massing refers to the built mass that occupies a site and is crucial in defining typology, scale and grain of a site. Density and distribution affect the spread of mass across a given area which in turn creates a certain ratio of built to open space. These areas are of particular interest in parametric city-scale modelling as a means of defining design intentions in the early stages of the design process and structuring desired typological patterns and relationships. Massing and density modelling is used here as a means of diagramming 3D concepts. This limitation of scope to massing diagrams defines the first rule of the proposed parametric method.

Urban models need to cover multiple scales of consideration and critique during design. New insertions therefore, need to be similarly linked into existing networks in order to be successful and survive. The case studies have been formed on the basis that these levels of design can be classified under four scales of consideration: Region, Community, Block and Building (Galiana, 2010).

Traditionally, this scale-based design method is approached as a linear series of snapshots. Decisions can only be made at one point or scale and then manually updated and validated sequentially at each of the other three levels. A parametric approach can set routine assumptions and prevailing conditions as constraints. In effect this creates a single working scale, zooming sequentially in or out in scale of resolution. This framework allows for a single digital working model to be formed and tested at any scale as the design develops. As a result, instead of the scale or working medium dictating process, the appropriate workflow of design thinking, as determined by the designer, defines the design across all scales continuously (Figure 1).

An important distinction to make with this definition is between the scale of design resolution and physical scale. The four scales of design fall under the category of physical scale which is a literal translation, represented by ratios relative to real life (1:1). Design scale is more fluid, and although it generally adheres to the rules of physical scale it is more concerned with resolution of ideas and consideration in the design process. This distinction is relevant to the diagrams in

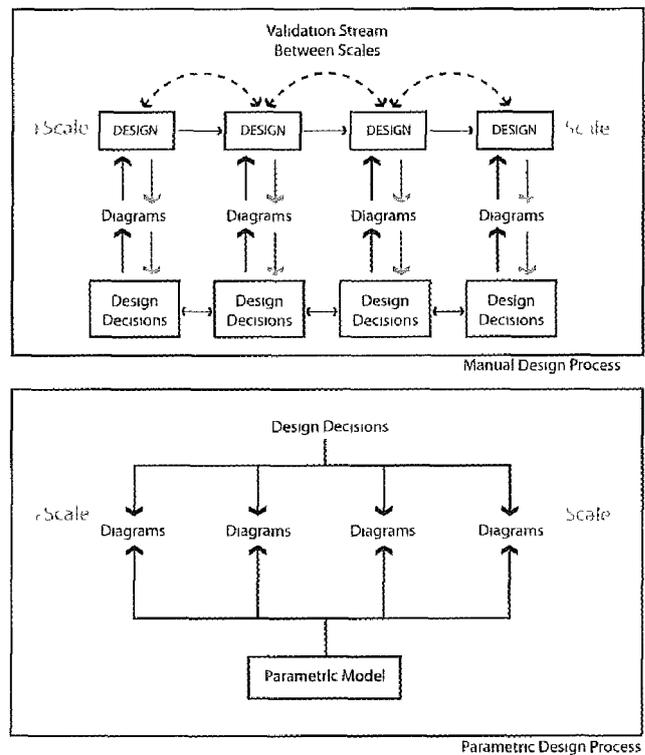


Figure 1. The manual and the parametric design chains.

Figure 1, because although parametric modeling has the ability to address all physical scales simultaneously, there is still a process of refining the scale of design thinking. This is still beneficial to the process as a design has only one shifting scale of linear consideration while the other is automated. Traditional methods require management of these two shifting streams, with design changes checked linearly back and forwards against each. This over complexity requires careful management of all current designs across all physical scale to ensure all are telling the same story and forming a singular, cohesive design.

4. Parametric Urban Design Methodologies

The following methods have been developed and tested across a number of urban scale studies and master planning exercises as well as a mix of both residential and commercial multi-storey building feasibility studies. The parametric generation reduces a large portion of the manual modelling processes as well as the measurements and calculation area schedules. This opens up the design process for more thorough testing of potential masterplan options as well as allowing for higher level feasibility testing on performance analysis, code compliance and

impact analysis. Each of these scales is presented individually to highlight the unique problems that arise in each. The end result is a single design modelling process that builds levels of detail as each finer grain is considered. The process of creating this master model is linear in terms of its macro to micro design process. Despite this, at any point in this timeline, the model can be considered as bi directional in its ability to simultaneously consider all data previously collated.

4.1. REGION

Regional scale design methods focus on analysis of existing site conditions and context as well as initial mapping out of design aspirations that will govern the subsequent finer grain decisions. Most of the problems that occur at this level of design are to do with the analysis of large, complex sets of conditions and constraints that will affect the design scheme. Whether the design is Greenfield or Urban Infill, the main aim of this phase of design is to gain an understanding of current state of play and begin to test the tolerances and opportunities for any new design addition.

Recent advancements in urban databases and Geographic Information Systems (GIS) have allowed for even more contextual information to be accessed than purely manual or visual assessments. The result of these collections of information is often too great to analyse manually but lends itself well to automated parametric analysis that can target and test specific data and return results that are relevant to a particular design. The design tools that have been developed and tested are classified under the headings, Existing Conditions Analysis and Design Intervention Tools (Figure 2).



Figure 2. Levels of regional design control and a resulting plan diagram for use as a parametric input.

The site analysis tools aim to return information about existing buildings and their relative importance, key nodes of activity, prevailing environmental conditions, infrastructure, servicing and geological data. Each of the tools that have been developed has aimed at returning the raw and often numerical data to the designer in a form that is more easily understood, manipulated, and communicated.

The key to the success of these tools has been to develop a simple language of diagramming the existing conditions analysis along with new design ideas from physical to digital mediums. From this format, the information can then be managed in a single parametrically governed model. The design studies have utilised a relatively simple form of substitution to inform the model with both perceivable and imperceptible data. Colour is used as a perceivable means of communication, defining different changes in the model such as key nodes, zone types or networks. As a means of communication, definitions by colour are the easiest form of communicating to human participants as well as having the ability to be understood numerically or digitally. The imperceptible information can take different forms, but is most readily understood as layers or object classifications. This type of data classification is imbedded in the live diagram and controls aspects of the design that does not need to be visually communicated or allow a base classification of design parts when the perceivable outputs are variable.

4.2. COMMUNITY

The community scale design tool is a means of applying indicative sites within the previously defined design zones. These general massing envelopes are governed by regional governance, building type compositions within zones and any of the relevant Existing Conditions Analysis as well as adding mass to form a full 3D design diagram (Figure 3).

Division and subsequent massing are controlled by variable parametric algorithms controls by community scale precedent benchmarking.

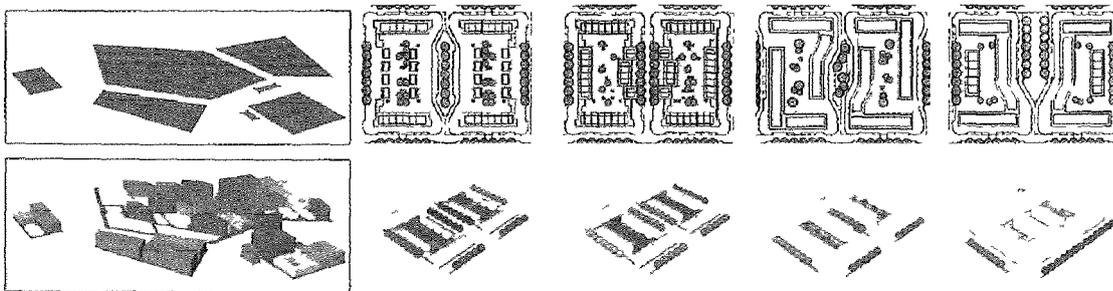


Figure 3. Community zone division and massing envelopes.

The basic zone forms are taken from the regional scale design diagrams. These regions are analysed for type and size and divided into basic block and building scale parcels. This stage sets the basic envelope footprint and height constraints for later stages and tests the overall site composition and capacity against contextual information, planning governance as well as visual impact and design analysis.

4.3. BLOCK

The block scale design application adds standardised building types into the envelope constraints defined in the community studies. This level of application relies heavily on external benchmarking information in order to test the potential success of different design aspirations.

This type of block composition studies can often be conducted in isolation from the parametric process. Type and typologies can be benchmarked and catalogued in order to test new schemes quickly. From this type of study, design aspirations for a new scheme can be quantified as general building data that can inform zone arrangement and the composition of the blocks they contain (Table 1).

The modelling process for this is very similar to that of the previous community scale massing phase. The main points of difference are in the benchmark or case study derived input information and the ability for the parametric tools to generate varying type clusters based on variable control inputs.

Table 1. Example breakdown of building types and distribution as determined from benchmarking studies (Figures Courtesy of Grimshaw).

	Mix	Beds	Sq ft	Sq m	Parking
Detached	5%	3	1050–1250	98–116	2
	5%	4 to 5	1250–1600	116–149	2
Semi Detached	15%	3	925–1050	85–98	1(50%) to 2(50%)
	20%	4	1150	106	2
Terrace	15%	2	750–900	69–83	1
	20%	3	950	87	1(50%) to 2(50%)
Flats	10%	1	500–550	46–51	0.7
	10%	2	650–700	60–64	0.7

4.4. BUILDING

The purpose of this level of modelling is to more accurately address aspects of building design requirements within the constructs already set during design

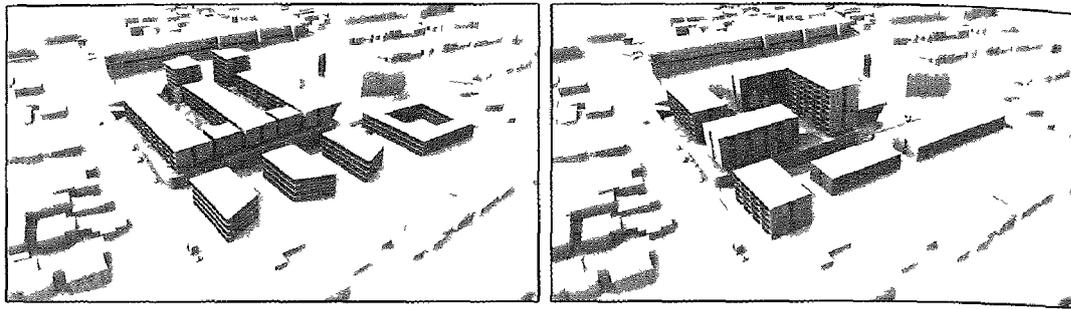


Figure 4. *Examples of Parametrically Defined Building Options. (Image Courtesy of Grimshaw).*

development. In some aspects this scale has proved most difficult in the development of parametric design tools. This scale of design is often too great to apply across an entire master-planned design but has proven useful for testing key areas in a site.

The results of these snapshot studies can then be generalised to further inform the block level design inputs. The following methods were, therefore, developed over a number of smaller scale feasibility studies and were aimed at very quickly testing built mass, site capacity and yield as well as visual impact of any new development. The model, demonstrated in Figure 4, was an optioneering exercise that was aimed at testing the potential Net Lettable Area (NLA) yield of a given urban zone and the resulting impact on the surrounding context.

As opposed to other scales of design, this phase was more closely linked into the excel file as a means of both outputting and inputting information. The results of this level of massing information were much more sensitive so the model required a means of directly changing yields to meet lettable goals. In the demonstrated case, subsequent changes to yield were seen in the relative heights of the building mass but could just as easily be programmed to expand floor plates outside the predefined block restraints through horizontal controls (Figure 4). Through a set of pre defined type constraints, the model could either report back or be controlled by building mass to open space ratios for the site, heights, building separations, light access, plant and core requirements, circulation as well as unit numbers, sizes and/or commercial NLA. It is the intent to avoid any building specific architectural design response and make the output imagery clearly typological and demonstrative. A minimum of building information is generated by this set of parametric tools.

5. Conclusions

This paper describes a method for addressing practice based urban design through the utilisation of digital and parametric mediums in the design process. This

method utilises simple diagramming formats with imbedded information that is readable by designers and stakeholders as well as the computer analysis and generation tools proposed. This approach allows designers to streamline workflows by eliminating the need to convert, redraw, or alter design information in order to communicate between human and digital formats.

Benefits of the parametric design process have been in the single live model that has the ability to interpret input data and output readable formats for further work across all four scales of consideration. This process is aimed at minimising data loss and misinterpretation through the import, export and communication of a design. The design method proposed still follows traditional practices of design thinking in macro to micro processes. Unlike traditional linear methods of design, at any point in the design timeline, the process is bi directional and self critiquing.

Some of the benefits of the embedded research process have been the identification of relevant design problems that affect practice as well as having constant checks and validation of design methods. This has led to a better understanding of the methodology, parametric tools and the resulting design outcomes. One of the disadvantages to this process has been the time constraints placed on live practice projects and the misalignment between client driven workflows and the required research and development of new parametric systems. This process requires multiple projects of a similar type to allow for development outside of a specific projects timeline while still enabling retesting against other new case study design problems as they arise.

Acknowledgements

The authors wish to acknowledge members of Grimshaw Architects Design Technology Group, Peter Liebsch, Daniel Fink and Michael Wu for their part in the development of the tools and methods described in this paper.

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