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Generating Urban Codes for Neighbourhoods

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Abstract: This research has developed a participatory methodology to generate urban codes to achieve the desired configuration for neighbourhoods in New Zealand. Urban codes are the qualities inherent in the built environment which have either evolved by themselves or have been guided by rules and regulations. The work develops a novel decision-making platform that brings together city level and local neighbourhood data to aid participatory urban design decisions. This platform offers stakeholder collaboration and engagement in complex urban design decision-making processes. The research develops a configurational design method by employing virtual instruments to generate building forms. The research methodology establishes a middle approach between top-down and bottom-up urban design methods where the generated urban forms can be visualised in an online platform for stakeholders to get real-time feedback. In particular, it explores an alternative urban design process as an algorithmic knowledge-based system for neighbourhood design.

Keywords: Urban codes; algorithmic urban design; decision-making platform; investigation rules; virtual instruments.

1. Introduction

New methods in urban design practices have brought about a shift from utopian design approaches to systematic design approaches (Beirão, 2012). Cities have ever increasing urban complexity and dynamics which have influenced a change in conventional urban design decision-making processes. Advances in procedural design approaches have already taken place in the domains of art and science, and such methods are starting to influence urban design (Beirão et al., 2012). With the advancement of computation, particularly in terms of Computer Aided Design (CAD), come rich possibilities to create design tools that address urban complexity. However, currently these tools are mostly used in design production rather than as an instrument in decision-making processes (Schnabel, 2007; Hanna, 2012). Previously, each design decision phases was carried out by hand, but nowadays they are automated (Miao et al., 2017). Such automatic design procedure also has influenced urban designers to seek for new design methodologies.

Shifting from top-down modelling to more generative and bottom-up systems has influenced urban designers to address morphogenetic changes in urban design (Beirão and Duarte, 2005; Ayaroğlu, 2007; Beirão et al., 2011; Verebes, 2013). Such systems can function as a creative design assistant during the conceptual stages of architecture & urban design. Traditional urban design and planning methods have

limited ability to address multiple urban complex rules and cannot able to provide necessary information to predict the urban forms. City Information Modelling (CIM) can automate design options and generate possible new urban scenarios (Gil et al., 2011; Beirão et al., 2012; Stojanovski, 2013). However, this top-down modelling process has the inability to visualise urban scenarios in a dialectic way for stakeholders (Kunze et al., 2012a). Therefore, this research develops an instrument between top-down and bottom-up design methods to engage stakeholders in urban design process. The research employs CIM and generates interoperable rules for neighbourhoods through mathematical and computational models by analysing and evaluating urban forms and spatial configurations. The research develops a configurational design method which can integrate maximum urban complex rules for building forms. The intention is to explore an alternative urban design process; an algorithmic knowledge-based system, in neighbourhood design.

The goal of the research framework is twofold. One is to develop an instrument which supports interactive prediction in urban design, and the second is to demonstrate a better way of communication between different stakeholders including professionals such as urban designers, urban planners, policy makers and lay people. The study presents an approach for how design codes can efficiently steer and redefine procedural city modelling to arrive at detailed urban scenarios (Kunze *et al.*, 2012a), and it also creates an interface to visualise the 3D models for improved dialogue between stakeholders (Kunze *et al.*, 2012b).

2. Methodology

The research methodology is a design exploration based on logical argumentation. The methodology comprises of five steps. It starts with defining the content of urban codes and end with an assessment process (Figure 1). The output of every step feeds into the next step. The first step extracts the content of codes. This step tries to reconfigure the contents of codes from literature reviews and exemplars. The second step configures algorithmic relationships between different urban elements and investigates them through several adapting methods from urban theories. The third step intends to develop a mathematical algorithmic modelling platform as programming scripts on the sets of investigation rules to generate urban forms. These algorithmic rules define the boundaries of design computing. The limits of design computing are indeed nebulous and difficult to define. Unlike pure mathematics, design computing is an application of computing–pattern which demands consistent interpretation and self-critique (Johnson, 2016). In this step, the rules translate to programming scripts. Such translation from physical rules to computation scripts provides an opportunity to operate those complex urban relations in a visual platform. Scripting in this step is an iterative process which engages stakeholders to predict the most desirable urban forms. The fourth step suggests a virtual platform to visualise the iterative outcome. Finally, the fifth step ensures the validation of output by an assessment process with stakeholders in an online platform to achieve the desired urban configurations.

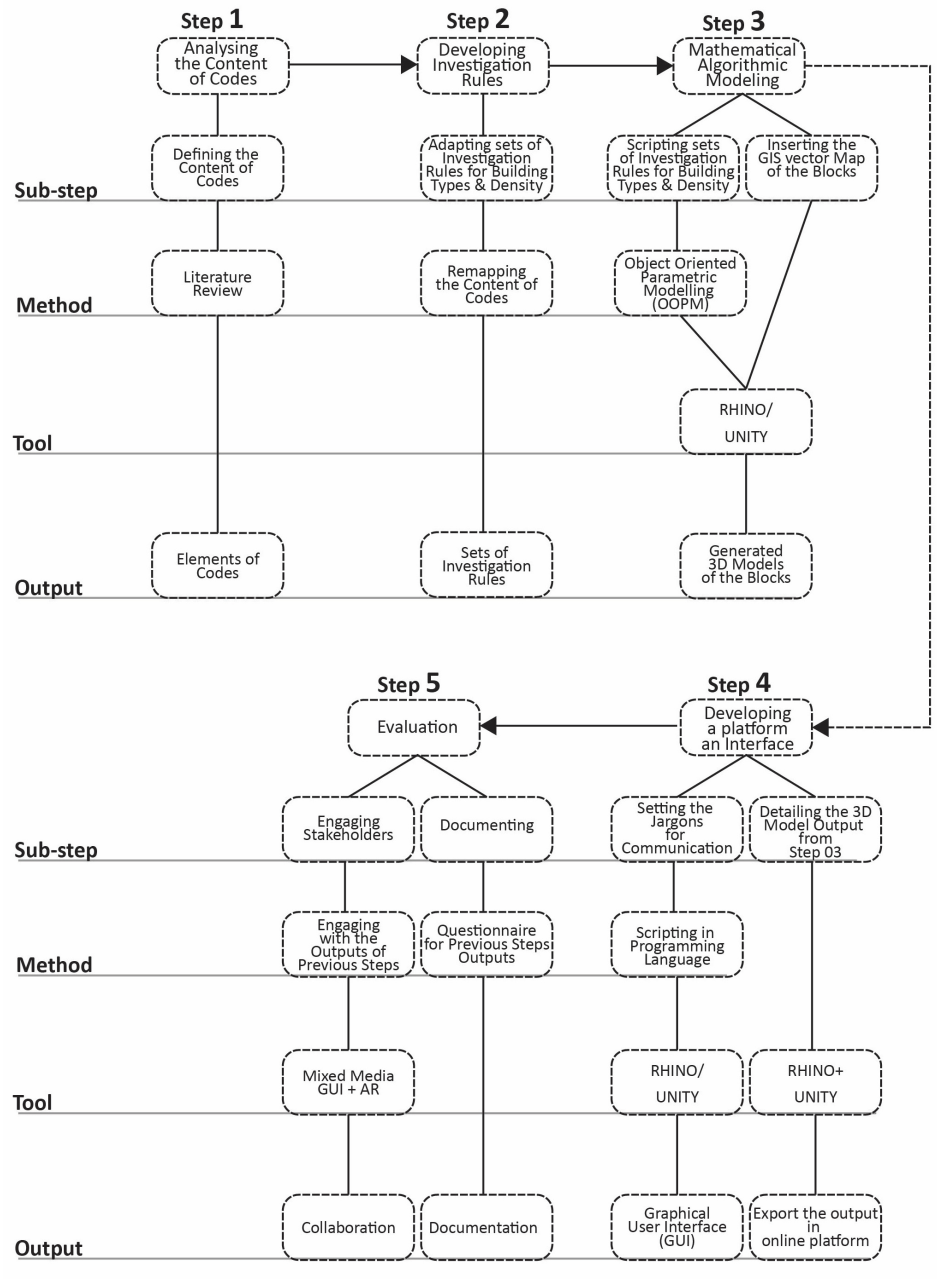


Figure 1: Research Steps

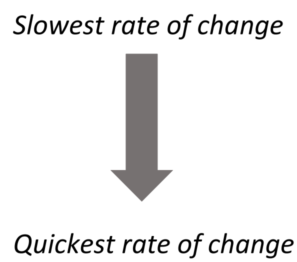
2.1. Step 1 - analysing the content of codes

Step 1 adapts the content of urban codes for this research from literature reviews.

Defining the content of codes

Urban components are associated with urban coding. Stephen Marshall (Marshall, 2012) has developed the framework for coded elements (Table 1) which he admits that the intention is not to produce an exhaustive synopsis of all codes and regulation, but is intended to contain the range of types of different coded elements. Within the scope of the thesis, this study adopts the primary content of codes which have physical impacts on street block formation. The elements are listed from slowest rate of change to quickest rate of change. So far, the coded items are:

- Open spaces
- Street network system
- Street width
- Street Block
- Subdivision of Lands in Blocks
- Plots/sections
- Subdivision of Plots
- Ground coverage
- Buildings height



The research addresses these content of codes to set the boundary of urban investigation rules.

2.2. Step 2 - developing investigation rules

Step 2 tries to establish the operable relation between different urban elements. The elements of urban codes posit an intricate lattice within themselves. Remapping the relationships of specific urban elements can set the boundary condition to operate them on a virtual platform. This section of the research explores multiple ways of remapping the relationship of the quantified elements of urban codes.

Adapting algorithmic investigation rules

The first set of investigation rules supports the parameters related to measuring physical density, which to some extent defines different housing typologies. Later, this stage includes the set of examination rules for street network and connectivity by employing space syntax (Karimi, 2012; Van Nes et al., 2013) and the rules for spatial configuration of dwelling functions by adapting graph theory (Nourian, 2016). Further rules like evaluating solar insolation, shadow analysis, functional mixture, etc. can accommodate in this part of the research framework. Most of these methods are simulation based. All of these investigation rules are purposefully designed to create urban scenarios which can simultaneously get feedback during the process of simulation.

A set of investigation rules for building types and density

Marshall illustrates that the elements of 'the scopes of building' and 'plots & land division' have the first-degree relation to formulating their physical aggregations. And the density indicators also depend on the value of those elements of codes. By remapping the relationship of coded elements, we can define the measuring criteria of density. Those elements also can determine the types of housing whether it is semi-detached, terraced or apartment.

2.3. Step 3 - mathematical algorithmic modelling

The insertion of mathematical modelling in urban design and planning has opened up a new horizon in design exploration. Mathematical modelling science refers an accumulated nature of knowledge which represents ways to comprehend and make sense of the complex relation (Lucio-Arias and Scharnhorst, 2012). Researchers like Koenig and Schneider (2012) have already started to explore the potentiality of the integration of cognitive computing in urban design and planning. Also, researchers like Schnabel *et al.* (2017) have already explored the potential applicability of parametric design in urban regulation. This part of the research transforms the previous set of rules in the programming language. Such transformation of rules in the computational platform provides the opportunity to operate the relationships between different urban elements and generate visible outcomes which eventually increase the interrogation with the design options in a real-time feedback.

A set of investigation rules for building types and density

This section of the research develops an integrated script from which one can generate the desired housing typology by manipulating the density indicators. The method is Object Oriented Parametric Modelling (OOPM). The script is written in a programming language either it is visual (i.e. Grasshopper for Rhino/ Dynamo for Revit) or C-style language.

2.3. Inserting the vector map of the street block

The script is linked with the 3D modelling interface by the GIS or Open Street Map (OSM) exported vector map of the street block of the test site. The script also accommodates the information of the topography. The map is available in online and has sufficient information to meet the requirement for this investigation.

2.4. Step 4 - developing a platform-an interface

From the beginning, the study tries to develop communicative Graphical User Interface (GUI). This interface offers a platform to operate and visualise multiple options of urban scenarios which are generated by various inputs. There are existing software like Rhino, Revit, Maya, etc. which can generate 3D models from programming scripts. The scripted rules from the previous stage, importing in such visual platform can create multiple choices for 3D models in an iterative loop. However, these platforms are still in the face of developing to overcome the limitation of engaging with the users. Figure 2 illustrates a GUI interface to generate urban forms in Rhino platform.

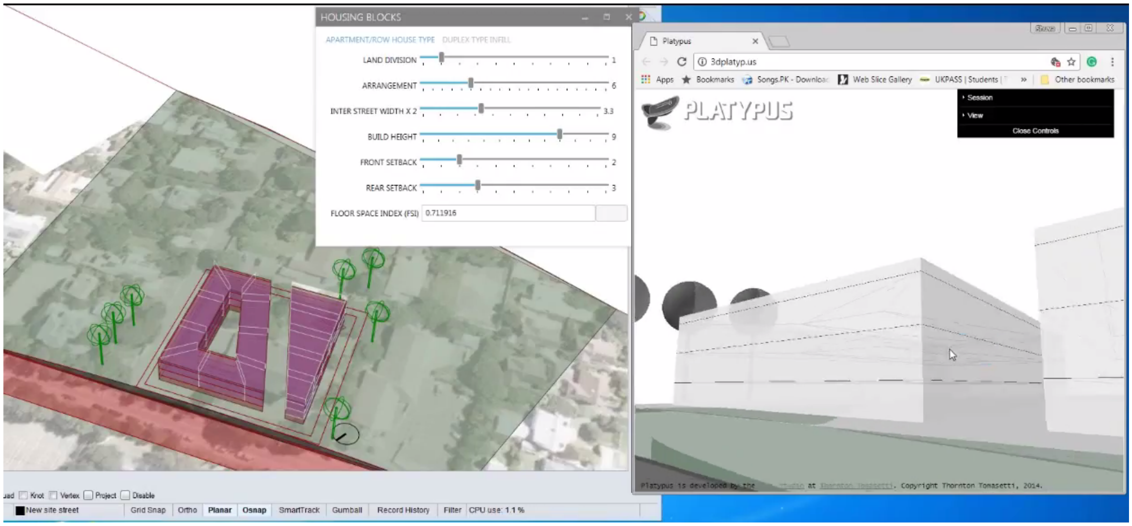


Figure 2: A GUI interface linked in an online platform to visualize generated urban forms

2.5. Step 5 - evaluation- assessing in a triangulation loop

This stage of the research validates the level of performance of this proposed system. The validation occurs with the presence of stakeholders. The online real-time visualization engages stakeholders in design discussion. This section suggests a triangulation loopbetween three different situated conditions (Figure 3). One condition is the input value in the system as density criteria; the second condition is the output of the system-the generated urban forms and the third one is the feedback from the stakeholders-their choices for urban forms. All three steps offer the state of negotiation, where the stakeholders initiate the decision of choices.

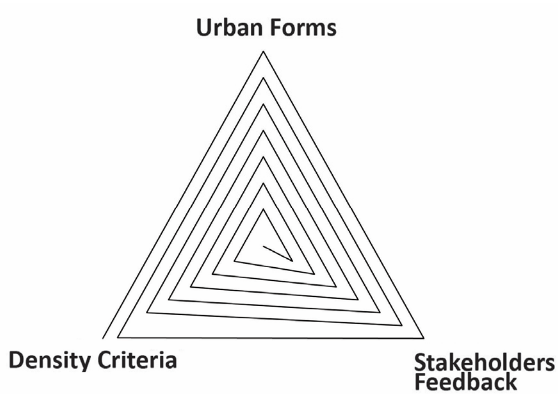


Figure 3: The triangulation loop for assessment

A triangulation assessment method provides a way to validate the conclusion of a study. Therefore, the assessment ends by getting the most desired urban scenarios after going through several cycles into the system. The evaluation of the system is concluded by documenting a questionnaire survey.

4. Contribution and discussion

The study is a significant endeavour to promote a participatory urban design system for neighbourhood design. The study develops an instrument to analyse and generate urban forms and present them with information to the stakeholders. The framework of the study also can be explored in the field of architecture and urban design pedagogy as a guideline for design studios or workshops. The steps of research methodology are framed in such a way that the methodology can cater to any location around the world. The sets of investigation rules offer to deal with urban complexity as a holistic approach, and the online platform offers to visualise the outcome in a dialectic way.

Urban professionals try to engage stakeholders in their design process through different approaches. There are already established studies to proof the limitation of perception of scales between top-down and bottom –up urban design approaches. This study doesn't include the socio economic aspects of those urban design and planning approaches, but seeks a methodology to create virtual instruments to bridge the gap. This study still needs proof to validate the system. The proposed system is on the process to engage stakeholders in real-life scenarios.

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