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**An Alternative Means to Generate Urban Codes:
An Instrument for Urban Design**

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ABSTRACT: *This study seeks to develop a methodology to generate urban codes to achieve the desired configuration for neighbourhoods. Urban codes refer to the embedded quality of urban forms which either evolved by itself or is guided by rules & regulations. The novel instrument proposed in this paper brings together city level and local neighbourhood data to aid participatory decision-making in urban design. We utilise an alternative integrated approach to investigate urban forms in a design procedure. Regarding design decision-making, there is a gap between top-down and bottom-up urban design approaches. On the one hand, the top-down urban planning methods define urban forms as a holistic matter which only can be calibrated by urban professionals. Lack of visual information in such approaches causes difficulty for end users to predict urban forms. On the other hand, the bottom-up approaches cannot provide enough information on urban scenarios, where the decisions mostly stay as general assumptions. Therefore, we speculate a middle approach to generate urban forms taking advantages of computational tools to engage stakeholders in complex urban design decision-making processes. This study concludes with a mixed methodology of top-down and bottom-up urban design approaches. We create a method for urban professionals to convey their design ideas on urban forms with visual information in an increased communicative channels for design discussion with stakeholders. At this moment, we are adapting density rules and creating communicative interfaces to generate urban forms by operating density parameters. The methodology can cater any location and can adapt other design rules corresponding to physical parameters of urban forms.*

Keywords: *Urban forms; parametric urban design; holistic urban planning; a decision-making platform; a knowledge-based system*

Introduction

Decades of studies on urban design are looking into the democratic involvement of different stakeholders in a broad variety of collaborative and participatory design decision-making platforms. Traditional urban design techniques can’t offer flexibility to cater the wide range of social issues in the design process (Kiddle, 2011). Methods like design charrettes and planning workshops already have seen their good days in such democratic engagement in design platforms (Batchelor and Lewis, 1985, Steinø et al., 2013, Knevitt and Wates, 1987). However, in spite of having such established methods, there are still differences exist in thinking and communicating language between professionals and laypersons (Friedman, 1973, Forester, 1988). The lack of engaging ways eventually pushes researchers to rethink for a new form of design-decision making platform where non-designers can fully understand the spatial implications of planning and design decisions. Previous collaboration methods have a stance on developing concepts in early design phase which can’t demonstrate engagement with the details of physicality. Relatively detailed architectural models either

physical or virtual can provide further collaboration between the professionals and the non-designer professionals or non-professional stakeholders (Steino et al., 2013). A computational virtual platform can overcome such communicative gap between practitioners and laypersons. An improved visual communication allows stakeholders in immediate and three-dimensional access to the design process (Chen and Schnabel, 2011).

Our research develops a design methodology that includes contextual urban parameters in a generative system. Urban codes are the embedded quality of urban forms which either evolved by itself or are guided by rules and regulations (Marshall, 2012). The study extracts the contents of urban codes as urban parameters for both high and low-density neighbourhoods. Our research considers the regulatory parameters of Tsim Sha Tsui (TST), Hong Kong and Karori, Wellington. The study creates a platform for stakeholders to visualise multiple urban forms by operating density parameters for both high and low-density contexts.

Background: An Algorithmic Urban Modelling

Shifting from top-down modelling to more generative and bottom-up systems has influenced urban designers to address morphogenetic changes in urban design (Ayaroğlu, 2007, Verebes, 2013, Beirão and Duarte, 2005, Beirão et al., 2011). 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 (Beirão et al., 2012, Stojanovski, 2013, Gil et al., 2011). However, this top-down modelling process cannot visualise urban scenarios in a dialectic way for stakeholders (Kunze et al., 2012). 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. We explore an alternative urban design process; an algorithmic knowledge-based system, in neighbourhood design.

The design strategies for urban design and planning take a lot of information and knowledge into account of the various types of complex urban issues which require visualising in the design process. Urban design is a complex phenomenon which deals with the participation of different conflicting agents. The lack of common language among such

agents raises communication difficulties (Beirão et al., 2011). The addition of parametric design develops an intelligent design system where that design becomes a computer model to understand how the different parts are related. Parametric Design along with BIM modelling system has already pushed architects to go for a new endeavour in building design. Such design method offers distinct advantages for engineering and manufacturing processes (Schnabel, 2007). BIM comprises an integrated system that aims to incorporate all aspects of design from geographical information, to building geometry, to the relationships between components and, to the quantities and detail properties of building components (Montenegro and Duarte, 2009, Guarino, 1998). The ontological description corresponds to city design process demands for creating City Information Modeling. CIM allows a holistic approach to deal urban design on a large scale scenario. However, industrial development in city modelling (Autodesk, McNeel, ESRI, etc.) still not intuitive enough in switching scenarios to be performed well in a design charrette (Kunze et al., 2012).

CIM already extends its boundary by integrating Geographic Information Systems (GIS) as a decision and design support tools. There are already established research which describes urban design method that incorporates the stages of form generation and evaluation of urban models backed by CAD/GIS software platforms (Duarte et al., 2012).

Test Sites: High & Low-Density Cities

Density is one of the frequently used words in the field of urban design and planning. It refers to the binary number of inhabitants in the given urbanised area. Jane Jacobs proved that the vitality of cities comes from density & diversity (Jacobs, 2016). There are different models to analyse such density regarding population, dwelling unit, coverage, and land use. Density has perceived as an abstract regulatory mechanism to manage city growth. Apparently, densities correspond to different urban forms, and a particular urban typology can have different densities. However, such numerical value only can be applied to measuring units but aren’t able to define qualitative aspects of urban form.

We choose Tsim Sha Tsui (TST), Hong Kong and Karori, Wellington as investigating sites. They represent two different density situations. Here, we aim to indicate common elements of urban codes and imply them as operable parameters to generate urban forms.

TST area located at the south tip of Kowloon peninsula. This area has developed from a fishing village since the 1840s (Fig.1). There are two reasons lead TST to a crowded urban core zone of Hong Kong. One is the water transportation, and the other is war. Because of the warfare of last century, a large number of population moved to Hong Kong. The special geographical location and history affairs made TST becomes one of the most crowded places in the world.

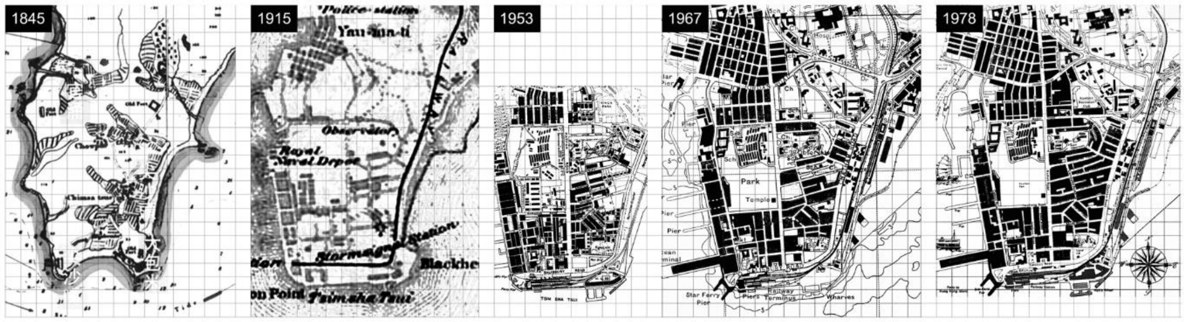

Figure 1 The urban development of Tsim Sha Tsui

The building forms and functions of TST are complicated because of extreme land-hungry situation. For instance, the Chungking Mansion created a dynamic and chaotic space with homes, small companies, stores, restaurants, as well as underground transfer points.The space users tend to utilise the building space by fully installing multiple functions. Tall buildings are encouraged by the current regulations of Hong Kong. Rules on plot ratio control density by manipulating building height and site coverage (Table 1).

Table 1: A comparison between low and high buildings

	Site Area	Storey	Each floor area	Height	Plot Ratio	Site Coverage
Building A	1,000m^2	6	720m^2	18m	4.3	72%
Building B	1,000m^2	25	400m^2	75m	10	40%

Based on Hong Kong’s existing Building Planning Regulations (BPR), the main parameters include heights, site coverage, plot ratio, open space and lands, as well as projection codes, like eaves, cornices, mouldings, balconies and canopies over streets, and use of verandas or balconies. Each variable has specific requirements for specific sites. The site classification consists of three categories. Table 2 illustrates height regulations for both domestic and non-domestic buildings in Hong Kong.

Table 2: An example of height regulation in Hong Kong-18A, 20&21, BPR

Height of building in metres	Domestic buildings						Non-domestic buildings					
	Percentage site coverage			Plot ratio			Percentage site coverage			Plot ratio		
	Class A site	Class B site	Class C site	Class A site	Class B site	Class C site	Class A site	Class B site	Class C site	Class A site	Class B site	Class C site
Not exceeding 15 m	66.6	75	80	3.3	3.75	4.0	100	100	100	5	5	5
Over 15 m but not exceeding 18 m	60	67	72	3.6	4.0	4.3	97.5	97.5	97.5	5.8	5.8	5.8
Over 18 m but not exceeding 21 m	56	62	67	3.9	4.3	4.7	95	95	95	6.7	6.7	6.7
Over 21 m but not exceeding 24 m	52	58	63	4.2	4.6	5.0	92	92	92	7.4	7.4	7.4
Over 55 m but not exceeding 61 m	34	38	41	6.8	7.6	8.0	60	62.5	65	12.2	12.5	13.0

Figure 2 Aerial view of Karori Centre (source: www.stuff.co.nz)

The complexity of density stems from the multitude of definitions of the term in different disciplines and contexts (Ng, 2009). In Hong Kong, the value of plot ratio commonly reached 10, while in Australia and New Zealand, plot ratio 3 is already a quite high-density value. Karori is one of the largest neighbourhoods in New Zealand (figure 2). Compared to other suburbs, Karori has good amenity and facilities but fails to integrate the attributes of place-making (Dodge, 2017). Currently, Wellington City Council (WCC) is focussing on Karori to develop a collaborative decision-making instrument which can stimulate interest and participation of the local community in the development of medium-density housing close to town centres. WCC already have proposed new building standards for medium –density housing in Karori (table 3). The draft indicates WCC is looking for a new regulatory system for building construction to transform Karori as a medium density residential area.

Table 3: A Draft of Medium Density Residential Area (MDRA) building standards (Wellington City Council, 2017)

	Current standards	Proposed
Building Height	8m	8m, with scope to build to 10.4m in certain scenarios, e.g., along Karori Road or close to a Town Centre
Building recession planes	2.5m on the boundary and incline of 45° on all boundaries	2.5m and an incline of 56° or 63°
Site Coverage	35%	50%
Front yard	The lessor of 3m or 10m less half the width of the road	3m
Open space	50m² per unit	20m² per unit
Vehicle parking	one space per unit	No change

Karori consists of a town centre, community facilities, schools, open spaces, commercial facilities, and multiple public transport lines. Through a field investigation, we have found that the community’s vision includes low-storeyed control, local character maintains, sunlight access, and open space guarantee. According to the Housing Choice and Supply of Karori, WCC, the main regulation parameters of Karori include building storey, height, recession planes, site coverage, open space and setbacks.

Table 4: A regulation parameter comparison between TST and Karori

Main Parameters (● Include, ○ Exclude)		TST	Karori
Building height		●	●
Building storey		○	●
Open Space		●	●
Plot Ratio		●	●
Projection Codes	Eaves	●	○
	Cornices	●	○
	Mouldings	●	○
	Balconies	●	○
	Canopies over streets	●	○
	Verandas	●	○
Setbacks		○	●
Recession planes		○	●
Site Coverage		●	●
Site Size		●	○

Table 4 presents a regulation parameter comparison between TST and Karori. Through the contrast, we have found that building height, open space, plot ratio, and site coverage are common in both TST and Karori. These are the elements of urban codes to define urban density. We have developed our computational platform on these density parameters.

Research Methodology: A Knowledge-based System

The research methodology comprises four steps. It starts with generating urban rules and ends with an assessment (figure 3). The output of every step feeds into the next step. The first step develops the investigation rules between urban parameters (Schnabel, 2006). The second step transforms those rules into interoperable 3D models. The third step suggests a virtual platform to visualise the urban forms. Finally, the fourth step ensures the engagement of stakeholders in a web-based platform. During the design process, reflections and iterations define the design itself (Chen and Schnabel, 2011). Our proposed methodology gets internal

feedback from the output of the computational simulation and external feedback from stakeholders.

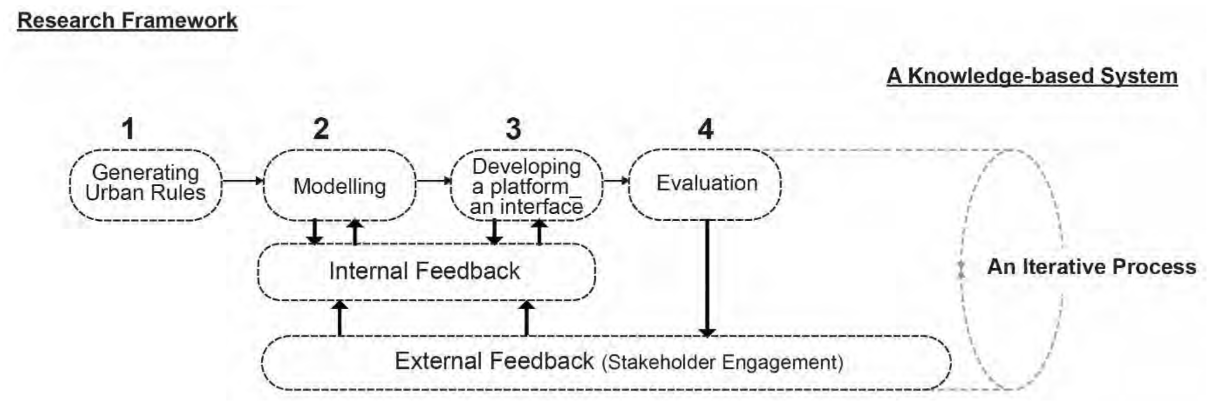

Figure 3 Research framework

Generating Urban Rules

This step establishes the operable relation between different urban parameters. The urban parameters posit an intricate lattice within themselves. At this moment, we are developing the computational rules on density criteria. We are taking the extracted urban parameters from the comparison of TST and Karori (table 4). We also adopt the parameters of plot ratio by employing form-based codes as vertical transects for TST (Schnabel et al., 2017). This step can cater more rules according to the need of the stakeholders' investigation.

Modelling and Developing a Platform- An Interface

This step translates the relationship of urban parameters in a computational platform as programming scripts to generate urban forms. The method is Object Oriented Parametric Modelling (OOPM). The script has written in a programming language like Grasshopper. The script has linked to the test sites by GIS or Open Street Map (OSM) generated vector maps. As we are examining TST and Karori, so we have linked our scripts with the vector map of desired locations of TST & Karori. 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.

From the beginning, the study is developing 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. We are using Grasshopper for Rhino to generate real-time urban forms.

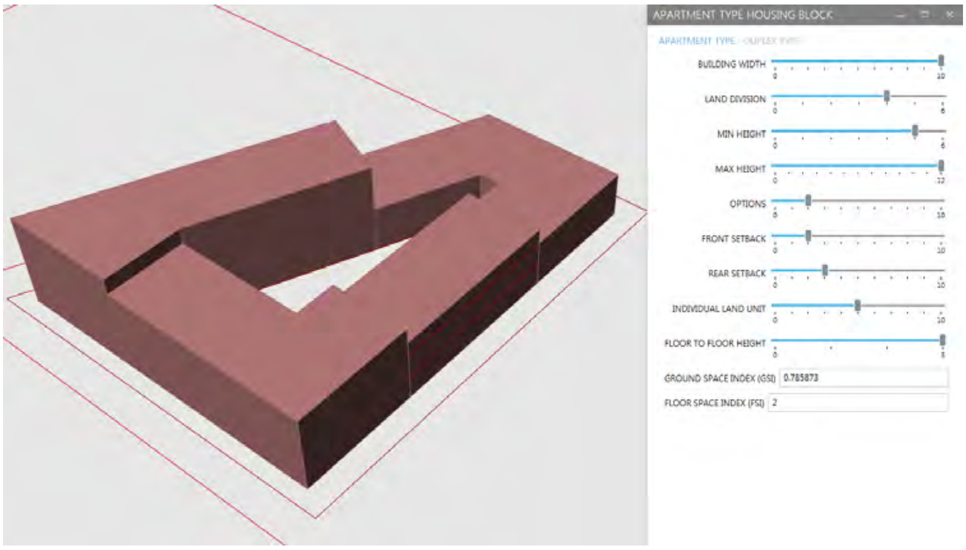

Figure 4 A GUI interface to generate urban forms (developed in Grasshopper 3D for Rhino)

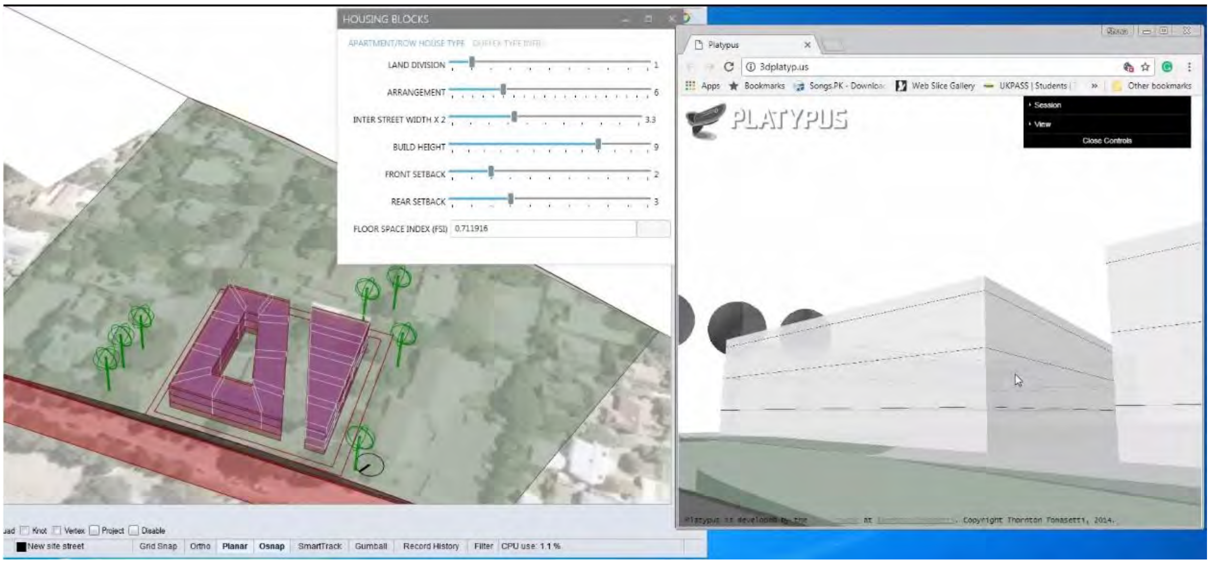

Figure 5 A GUI interface to generate housing types for Karori and visualise in online to get real-time feedback

We have developed several interfaces to visualise urban forms in online platforms. Figures 4 & 5 illustrate design platforms for Karori where a change in urban parameters in the interface provides a real-time output in online. Such online platform encourages distant collaboration between stakeholders. The parameters in the interface indicate the density values. The script has designed in such a way that the density indicators regarding plot ratio

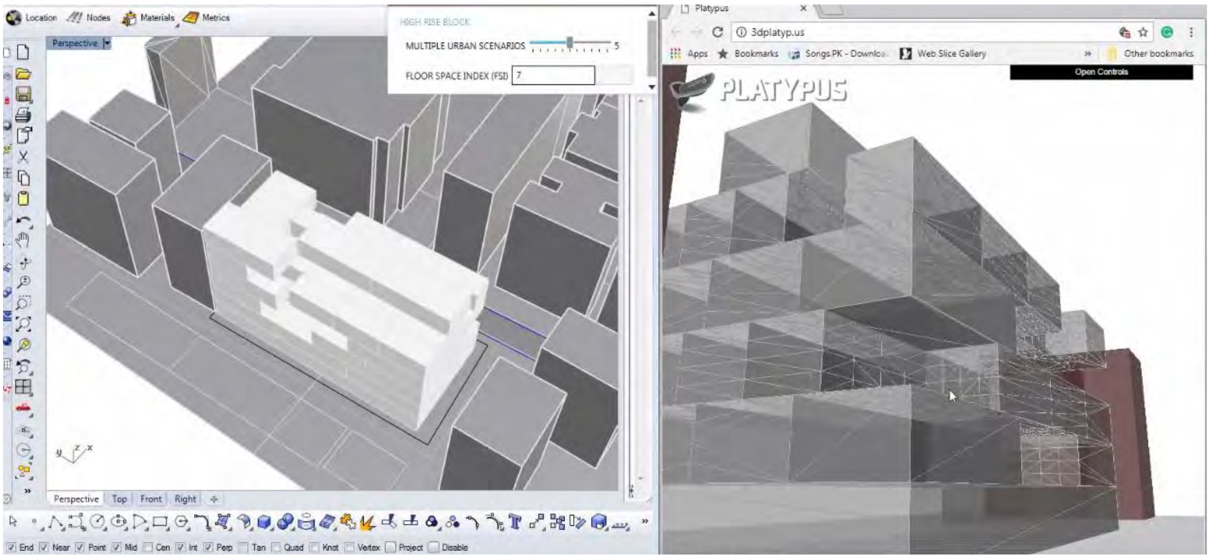

Figure 6 A GUI interface to generate building forms by manipulating Plot Ratio for TST and visualise in on-line to get real time feed back

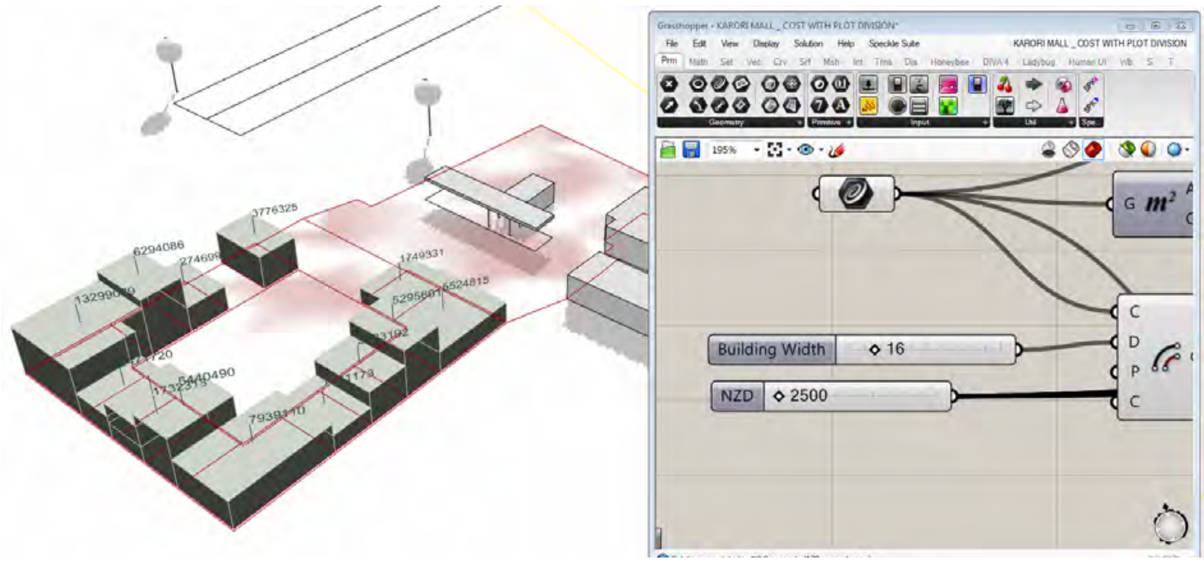

Figure 7 Visualizing Karori Mall with construction cost per square meter by changing the building width and height. The cost per unit also can be changeable as per as the requirement of the stakeholders.

can generate new urban scenario for every single input in the sliders. The information on density helps stakeholders to decide which kind of urban forms they want to have for their neighbourhood. Similarly, figure 6 illustrates another platform for TST where the interface provides the information of multiple urban forms regarding plot ratio. Recently we have developed another script to visualise urban forms with the information of construction cost and building energy for Karori mall (figure 7). This platform offers to envision multiple urban forms for Kaori Mall precinct through online collaboration.

Discussion

Software like CityEngine also deals with such procedural modelling but provides a limited interface for editing the regulation parameters without any analysis features (Bum Kim et al., 2011). Similarly, CityCAD does not offer programming interfaces that allow its extension (Gil et al., 2011). In some extent, ArcGIS can work as a data editor and container of physical elements by using point, line, and polygon but demonstrate inaccuracy on the generated data. Compare to all of these tools; our proposed method shows more flexibility to cater multiple urban rules for urban professionals. However, further study requires validating the process in urban design charrettes.

The occupied challenges of digital technologies are as dialectic interfaces. Digital technologies are continually evolving to accommodate dialectic nature with reality which promotes innovative ways to interact with end users. A problematic issue for parametric design approach, in general, is that it never resolves all the parameters which are necessary for design. Urban professionals still need to elaborate most parts of the design in their mind. Another problem of parametric programs that they have been designed and attached with traditional workflow in alignment with process thinking not intuition. Hence, the operators of these systems have to anticipate the project directions beforehand to create geometry and to build the inter-relationships. According to Aish and Woodbury (2005), parametric modelling embraces unnecessary complexity with too much information on items. Additionally, the design decisions are usually made by an algorithmic process, not by the designer (Terzidis, 2006).

Conclusion

Urban planning and design always deal with complex issues of urban forms. Throughout decades, urban professionals are working to engage end-users in their design process. But, most often all the participators aren't able to predict the urban forms as they deal with such complex relation either a top-down process or a bottom-up process. This study bridges the scalability gap between these two design methods. The methodology embraces parametric design tools as well as online communication methods. We propose a robust computational urban design approach which can cater new design rules for different locations. That means, this platform offers urban professionals to create unique design rules between urban parameters and can produce and convey multiple design ideas to their clients. This study presents an interface where numerous urban parameters can be operated. So that, stakeholders

can participate and select which kind of urban forms they want to have for their neighbourhood. The value of the urban parameters defines the urban regulatory inputs where a change in one parameter affects the whole urban scenario. The generated outcome can visualise with relevant urban information to help the stakeholders to decide their desired urban forms. Bottom line; this study proceeds for further exploration for a participatory parametric urban design instrument.

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