A Communication System in Urban Design Process: An Algorithmic Neighbourhood Design Approach

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Abstract

Our paper questions the aspects of design communication in urban design practices of both conventional and participatory design approaches. We offer a virtual design methodology to generate urban form as a middle approach between conventional and participatory urban design processes. We hypothesise that a virtual participatory urban design platform can provide more design associated information for laypeople to participate in design decision-making. The conventional urban design approaches investigate urban form as purely through the lens of urban professionals. In participatory urban design approaches the design decisions remain as general assumptions because of lack of enough associated information like cost, building form and real-life visual perception etc. Therefore, we propose an approach to produce urban form taking advantages of virtual tools to engage stakeholders in complex urban design decision-making processes. We have created a platform to engage laypeople in design iterations system to compare and visualise multiple ideas at a time. We speculate urban professionals to design set of rules with parameters to produce and communicate design ideas. We have tested our platform for Karori, a neighbourhood in New Zealand. Our research presents an alternative urban design process as an algorithmic knowledge-based system for neighbourhood design. We conclude with a prototype and an overview of contemporary virtual design communication tools in the urban design processes.

Keywords

An algorithmic system, design communication, participatory design, virtual platform

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1. Introduction

Urban design denotes a process of creating form, shapes and characters to groups of buildings, neighbourhoods and cities. Urban design process always deals ever increasing urban complexity and dynamics which are interrelated and inter-dependent to each other. Such design approach seeks a better urban neighbourhood for its end users. In some cases, these design decisions are successful in producing lively urban environment. But, still, lack of visual information and tools in the design process doesn't allow stakeholders as well as end users to speculate the design ideas before that has built. Moreover, sometimes the design processes are cumbersome to address further details related to construction and post-occupancy period. This detailed information also does not help lay people to understand the overall design ideas. On top of that; the design systems have lack of iterations to offer multiple design ideas instead of one. In fact, it is impossible for urban professionals to address all of the aspects of urban dynamics. Our research looks into that drawbacks and develops a methodology by offering a platform for better communication and participation in the design process.

The study develops a design discussion platform to produce urban form by employing virtual tools. Quality urban design is that which response sufficiently to social, economic and environmental issues through the physical design. The conventional design approach has not had the tools to visualise urban form during the decision-making stage. Parametric design tools can offer a platform to visualise and analyse urban scenarios for urban designers and planners alongside stakeholders. These design tools and techniques are still evolving to accommodate the range of complex issues evident in the urban realm. However, there remains a disconnect between top-down planning processes and the real-life experiences of those who inhabit these neighbourhoods. Our research hypothesises that engaging stakeholders using a virtual design platform can reduce the gap between reality and conceptual design processes leading to a more favourable design outcome. Recent development of computation tools and accepting them in the design process has brought about a significant shift from utopian design approaches to more systematic design approach. These tools offer a ubiquitous virtual interaction platform to produce and visualise iterative design ideas. We, in our previous work, argued that a computational platform can accommodate maximum urban complexities in a virtual platform for design discussion (Chowdhury & Schnabel, 2017). This paper supports and extends that hypothesis with more supporting theories and testing.

As a case study, we have considered the suburb, Karori in Wellington. In Karori, Wellington City Council (WCC) has run year-long charrettes to understand the community interests and priorities and identify locations for further development ("The Karori Project," 2017; Wellington City Council, 2017). To date, the charrette process has generated a map of priorities within the Karori neighbourhood and the mall area has been signalled as a priority for redevelopment ("The Karori Project," 2017). Our research includes the mall site of Karori to produce new design ideas in a virtual parametric participatory platform.

2. Communication System in Participatory Urban Design and Planning Processes

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. Conventional urban design techniques can't offer flexibility to cater the wide range of social issues in the design process. Methods like design charrettes and planning workshops already have seen their good days in such democratic engagement in design platforms. However, in spite of having such established methods, there are still differences exist in thinking and communicating language between professionals and laypersons. 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. A computational virtual platform can overcome such communicative gap between practitioners and laypersons.

The participatory urban design process has brought the idea of the bottom-up approach. Healey (1997) points out the demands of public participation in decision-making for more accountability on the parts of stakeholders. It brings the shift from a top-down to bottom-up strategies in urban planning practices (Murray et al., 2009). Bottom-up, participatory urban design approach encourages direct communication in urban design. Participation, concerning design processes, can be defined as information exchange (Sanoff, 2000). The principle of participation in the idea that the process doesn't look for "best solution" to a design problem but rather seeks a range of solutions to design and planning problems. Bottom-up design approach encourages the process of local participation in every aspect of development. It involves local participants either through design consultation or by collaboration. Bottom-up approach corresponds to the existence of a community that has specific needs, problems and expectations which are different from other communities (Pissourios, 2014). Participatory bottom-up process loses its efficiency when the population size increases which slowing down the process of urban intervention and consumes more time in the process. In particular, the arrangement of gathering various stakeholders of the community in the open-ended discussion requires more time to reach an agreement. Thus, in large communities, the participatory bottom-up approaches are inefficient. Naess (2001) also argues that bottom-up approaches are unable to deal with super local facilities and their implementation becomes cumbersome. Thus, the top-down approach is inevitably the only available choice for regional and spatial planning practice, and bottom-up approaches are limited to the local planning of small settlements (Pissourios, 2014).

The conventional participatory planning process is based on pen and pencil, paper maps, photographs and physical models (Al-Kodmany, 2001). Such visualisation techniques still provide specific visual consequences of governing the design of data representation (Tufte & Robins, 1997). Visualization in urban context offers a method to see the unseen which enriches the process of scientific discovery and fosters profound and unexpected insights. Participatory design processes are based on these visualisation techniques. It is widely accepted that in communicating planning ideas, the form of representing the information is as important as the information itself (Al-Kodmany, 2001). Al-Kodmany argues that in urban planning is closely associated with geography, has a long history of involvement with computers. In the past few years, researchers have taken full advantages of computers in participatory design processes by producing three-dimensional graphics, virtual reality and web, at least at the stage of prototypes if not in planning practices. Arguments and counter-arguments are there for these explorations by raising the questions whether this kind of tools is best for communicating spatial ideas to encourage discussion and decision-making process with the public or not.

3. Virtual Design Collaboration Tools and Nature of Communication

Virtual-, Augmented-, Mixed-(VAM) modelling allows novel ways to merge real-life situations with the virtual information in the field of Architecture, Engineering, and Construction (AEC) Industries. It has offered a variety of instruments to bridge the gap between the idea of a design and its way of representation, communication and realisation (Schnabel, 2009). VAM comprises a variety of realms from reality to virtuality which has already explored by design professionals as useful interaction instruments. Developing computer support for collaboration in design means producing systems that can amplify the effectiveness of the collaborative team (Schnabel, 2009). The use of the pure digital tool confines the creativity in the design process, yet designers need the freedom to move smoothly back and forth between digital and physical realms using digital and physical tools in both conventional and unorthodox ways. Recent progress in these VAM tools allows interaction in a real-world environment by receiving computer-generated visual information. Collaborative VR and AR have already explored quite successfully in outdoor navigation by employing Latour's Object-Oriented Ontology (OOO), data management, data visualisation and GIS tracking methods (Reitmayr & Schmalstieg, 2004). Though these tools still has limitations on sharing information, it offers advantages in collaboration, natural interaction and integration of digital information in architecture and urban design (Seichter & Schnabel, 2005).

Urban Simulators already have introduced in planning for public participation as they tend to be flexible and can usually operate at any scale (Al-Kodmany, 2001). These technologies allow community members to understand and relate to city design on their own without the help of "experts". The primary drawbacks of this kind of tools are the cost and time investment required to create a simulation environment. George (1997) has also projected the proliferation of the use of hypermedia. One example of hypermedia is HyperSpace, which is a computer-based medium for communicating ideas or urban spaces that has been used in classrooms. It links to text, moving and still graphic images, digital video and sound in multiple ways. In a sense, HyperSpace offers a three-dimensional map of an area along with a method of recording reactions to a site from a wide array of users.

The prime aspects of virtual reality techniques are passive stereo, active stereo and interaction devices which represent fundamental experiential attributes, not of attributes of space as such. These support the way of perceiving spaces (by observing space with our eyes and ears); the way we are in space (by moving our body in space); and the way in which we practice (by interacting with objects in space) (Jensen et al., 2002). Virtual reality suggests a phenomenological conception of space. Our virtual reality application functions by their similarity with physical and social spaces. The developed conceptual model in a virtual environment is based relationship between different objects so that they can interact with each other. The conceptual modelling is intuitive enough to be understood by different stakeholders. In virtual environment, participants can interact with real scale mass models. The spatial perception of a specific area can enhance with such VR interaction. Virtual reality along with internet becomes a powerful tool for planning and public participation. George and Selvakumar (1998) argue that the combined approach of virtual reality and internet will be so effective to communicate to a large group of people to exchange design ideas in an experiential nature of the environment. However, Al-Kodmany (2001) criticises that web-based virtual reality for public participation lacks the benefits of face-to-face social presence. In fact, to develop such interface requires cost and high technical expert assistance which are stumbling blocks for incorporating this technology. Gosling (1993) emphasised the use of computer-generated video animations as one of the most effective ways of public communication. He also assumed that the implications of virtual reality in citizen participation in an interactive planning process could contribute a lot to the urban design processes. He argued that computer-generated images could provide meaningful graphics for non-professional people to understand new urban responsive design ideas.

4. The Importance of Algorithmic Approach in Design Process

Urban Design Ontology (UDO) defines the set of investigation rules in the realm of the computational design approach. As a philosophical term 'ontology' concerns with the study of existence. In general, ontology describes the concepts of a domain and defines the relations among them. Such domain comprises the specification for representing entities, classes, functions and relationships among components, which constitutes a knowledge-based boundary condition (Gennari et al., 2003). The production of ontologies provides a vocabulary for researchers to share information in the defined domain (Noy et al., 2001). Similarly, UDO concedes the idea of defining a domain of urban components (i.e. networks, blocks, zones & landmarks) and the relationship between them (Montenegro & Duarte, 2009). The essential characteristic of the ontological design system is the sharing of information. Montenegro and Duarte call this sharing the "shared knowledge" which promotes the integration of different urban rules as a recursive procedure under the same body of inquiry (Montenegro & Duarte, 2009). In the end, such process reduces the ambiguities between different results. Our work addresses the term "ontology" as "investigation rules". Our research adopts the concept of urban design ontology to develop the investigation rules which are relevant to the attributes of urban form. As Mitchell (1990) mentioned that an interface with details of systems for building and applying set of design rules are less important but suggested to focus on the expression of design rules in declarative, modular, easily understood and easily modifiable format. He emphasised on the graphically expressed shape rules could be programmed as knowledge-based design systems that allow quick and easy modification of rules. In other words, he was referring design systems as open, flexible, constantly evolving knowledge-capture devices rather than static collection of familiar tools and dispenses of established wisdom.

A computational or parametric design refers to a system where a domain of parameters can produce and visualise multiple options in an iterative process. Computational intelligence has already been explored and broadly accepted in the field of architecture, engineering and construction. Recent developments in parametric design influences urban researchers to incorporate computational technology in predicting urban form. The parametric method accounts for a prior procedural method in which the form is the outcome of a process. The positive sides of generative approach are that the algorithm can reproduce a schema with changes in dimension and configuration which eventually addresses a high complexity and ensures responsive relation to condition and environment. During the generative modelling process, each step in the design is analysed, evaluated and altered (Meier, 2012). Previously, analysis tools are often only used in the final stages, where it might be too late to impact the design. This is due to considerable time and effort typically needed to produce the analytical models required by the analysis tools. A computational modelling approach can integrate the analysing stages within the design process. So to do that, the computational steps has to incorporate the analysing parameters in the design process. Our platform combines some of the information of cost analysis concerning building location and building forms.

5. Need for A Combined Conventional and Virtual Visualisation Tools

In the literature, there is a mixed response to virtual visualisation. Most of the research agrees that there are lots of benefits of computer-enhanced community planning process (Al-Kodmany, 2001; McCormick, 1988). The foremost advantage is that virtual visualisation can accurately present and represent complex contextual information. The process can facilitate direct depiction of movement and change with multiple views of the same data. The user interaction with three dimension models and simulations provide an avenue for user to understand complex urban conditions. These design approach also capable of producing design alternatives which are unavailable with non-computerized method. In a public planning situation, virtual tools can visualise abstract environmental impacts which would be impossible with paper, photographs, or physical models. Moreover, virtual tools like GIS, hypermedia, virtual reality, etc., offer unprecedented access to a rich array of data which are in easy to understand format for group discussion (Shiffer, 1998). A further benefit of computer-aided visualisation for decision making for a neighbourhood design with a large group of individuals is that computer visualisation quickly moves the discussion beyond "where are we" and "what is there" toward more meaningful discussion of how something is likely to change. Shiffer reports cases where groups spent more time exploring the visual implication of change than talking about the physical characteristics of an area. Another key advantage of using virtual visualisation methods is the flexibility to present various scale shifts. The ability to zoom in and out provides visual information to think beyond the immediate neighbourhood. It also provides flexibility to display information selectively. Langendorf (1992) states that the amount of detail displayed in computerised programs can be adjusted interactively as the scale is changeable. Cristie and Berger (2017) are evaluating a method of engaging stakeholders in a multi-screen game like environment to negotiate and reach a consensus in planning discussion. Some researchers argue on the advantages of table-top digital planning tools in a real context (Petzold et al., 2014). Despite having lots of benefits in virtual visualisation, it invites less user engagement than the conventional tools. While such tools usually impress participants by comprehensive understanding of geographic area but they fall short of providing the user with the means to design and alter the representations. Moreover, still many people quite feel intimidated by virtual environment (Al-Kodmany, 2001). Additionally, advanced visualisation technology is not widely accessible to the people as most of the tools are expensive. Arguments are there on the use of World Wide Web (WWW) for mass accessibility. However, there are institutional issues like willing to participate in online planning process create hurdles. Another drawback of such virtual visualisation tools is that the images they produced can be misleading for people.

Conventional tools like scaled models and hardcopy maps allow people to focus on tangible and spatially representative objects by providing intuitive interaction through grabbing, moving, circling, pointing at, and marking objects during a discussion. This kind of tools already have proven effective in opening a process of dialogue with communities. However, virtual visualisation tools deal with accurate and realistic information of the context. Current researchers also suggest that the method should be developed on the requirement of the project goals. Because some of the project only requires to convince people for a certain individual development where other projects may require to find what to develop in their context. Therefore, taking into consideration of the availability of the technology and the level of acceptance to the virtual visualisation, a combined method of conventional and virtual tools will help to find more comprehensive design solution.

6. Developing the Prototypical Platform

A prototype allows testing of a hypothesis, confront theories, confront real-world situations and enable interventions to people to experience a situation which did not exist before. Our participatory prototype represents a tool combined with a map and the virtual instrument. We are investigating Karori Suburb in Wellington. The prototypical platform which we have developed can help community people to take comprehensive design decision for their city centre. Our methodology depends on three steps. It starts with defining the parameter development and ends with evaluation (Figure 1). The output of every step feeds into the next step. The first step finds the urban parameter relevant to Karori redevelopment from literature reviews, Wellington City Council (WCC) reports on community engagement charrettes and their strategic redevelopment plans. For this research, the parameters we have considered are building width, land division, building height, open spaces and no of trees. The second step develops the engaging instrument for design discussion. The instrument generates urban form with visual information which helps stakeholders in design consultation (Van Schaik, 2010). This step comprises three sub-steps. It includes developing investigation rules, mathematical algorithmic modelling and developing an interface. We have developed investigation rules in relevant to construction and demolition cost for the new proposal for a public plaza in front of the Karori library building, Karori Mall and no of trees. The fourth step produces an interface to visualise the iterative outcome. Finally, the fifth step validates the output by engaging stakeholders in design charrettes. In this step, we include a map of Karori centre to orient the community people for more

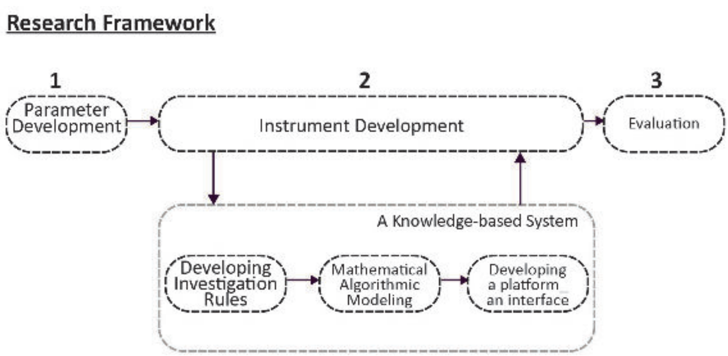

Figure 1: Research Framework

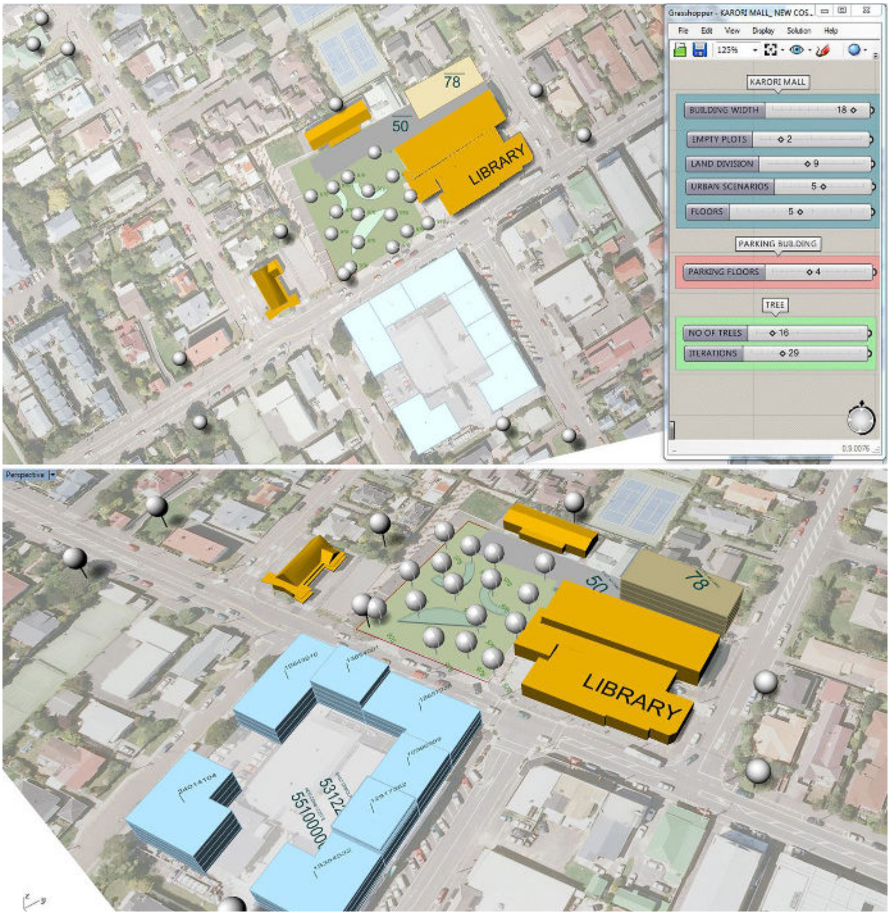

Figure 2: Visualising new urban form for Karori neighbourhood with associated information of construction cost, demolition cost, number of parking, number of trees and total planting cost

flexible design discussion. During the design process, reflections and iterations define the design itself (Chen & Schnabel, 2011) and computation and engaging people can enhance the process. Our methodology gets internal feedback from the output of the computational simulation and external feedback from stakeholders.

7. Testing Alteration

We have developed several interfaces for Karori Community Engagement. One of them is the platform to speculate new Karori Mall precinct relevant to construction cost, demolition cost and number of parking (Figure 2). We also have developed the communicative Graphical User Interface (GUI) in VR environment to engage people in generating urban form. This interface offers a platform to operate and visualise multiple urban scenarios for stakeholders' collaboration. The interface is linked through online which allow perceiving the urban form in different scales (Figure 3 and 4). We have extracted one of the iterated models from the platform and uploaded in World Wide Web (WWW) VR repository to let maximum number of people virtually immersed in the new design ideas (Figure 5). The model can be experienced through Google VR cardboard.

8. Discussion and Conclusion

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

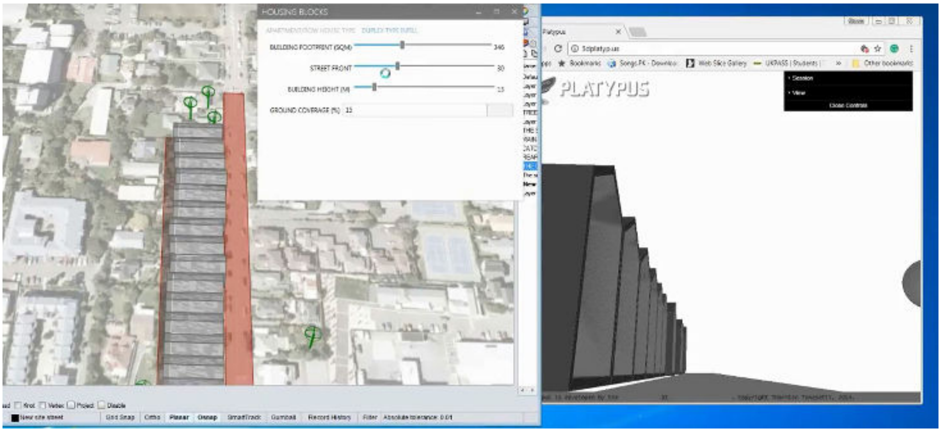

Figure 3: A GUI interface to create new housing types for Karori and visualise in online in different scale

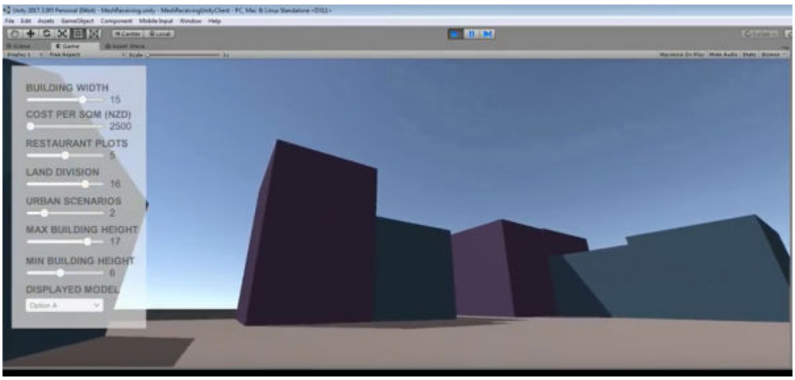

Figure 4: A Unity VR interface to create new Karori Mall relevant to the parameters of investigation rules.

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 conventional 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, 2011). The criticism on VR technology is that it limits the number of the participators as the headset types allow one participant per computer. Again, with VR there is a distinct lack of face-to-face involvement with other participants. Therefore, our platform adopts conventional sketching method on virtual interface to orient participators in design discussion. We include a sitemap of Karori neighbourhood to orient the community people and a sketchpad to enhance the design discussion (Figure 6). We provide some box modules for buildings and trees. We use digital sketchpad to convey design ideas on 360-degree views of google earth. To enhance the design discussion, we have linked the output of the sketchpad to a large display screen.

Urban planning and design always deal with complex issues of urban form. 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 form as they deal with such complex relation either a top-down process or a bottom-up process. Our study bridges the scalability gap between these two design methods. The methodology embraces parametric design tools along with conventional communication methods. The study presents a combined virtual

Figure 5: The extracted and World Wide Web (WWW) uploaded model to allow mass people participation in VR

Figure 6: A sketch board and Karori map with box modules

and conventional platform where numerous facets of urban dynamics can be dealt. So that, stakeholders can participate and convey their ideas on designing their neighbourhood. The virtual parametric platform allows to regulate urban regulatory inputs where a change in one parameter affects the whole urban scenario. Also, conventional sketching method on virtual interface helps to orient people in the context and conveys new ideas on their neighbourhood. We have scheduled ourselves for design charrettes to engage Karori community. The charrettes outcome also can reveal how a parametric urban form generation platform supports their decision on visualising their future neighbourhood.

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