DIGITAL CULTURE

An Interconnective Design Methodology Ecosystem

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Abstract. Transitioning away from traditional design methodology, for example, paper sketching, CAAD works, and 'flat screen' rendering, this paper proposes a new methodological ecosystem of which tests its validity within a studio-based case study. The focus will prove whether dynamic implementation and interconnectivity of evolving design tools can create richness and complexity of a design outcome through arbitrary phases of a generative design methodology ecosystem. Processes tested include combinations of agent simulations, artistic image processing analysis, site photogrammetry, 3D immersive sketching both abstract and to site-scale, parametric design generation, and virtual reality style presentations. Enhancing the process of design with evolving techniques in a generative way which dynamically interconnects will stimulate a digital culture of design generation that includes new aspects of interest and introduces innovative opportunities within all corners of the architectural realm. Methodology components within this ecosystem of interaction prove that the architecture cannot be as rich and complex without the utilisation of all strengths within each unique design tool.

Keywords. Methodology Ecosystem; Simulation; Immersive; Virtual Reality; Photogrammetry.

1. Introduction

Prevailing traditional architectural design methods, for example, paper sketching followed by CAAD works and standard 'flat screen' rendering, have since become too ordinary to acquire a unique richness of architectural design during the concept, development, and presentation phases (Kvan 2004). Architectural design advances from different approaches utilising evolving digital technologies which embrace not one, but many modern tools existing across a range of techniques. The aim of this paper is to propose a new architectural design methodological ecosystem within a framework which will be tested, and thus established to advance this common issue of lack of richness and complexity within architectural design projects, with the outcomes being highly resolved and intricate (Schnabel et

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al. 2004). Throughout this paper, research via experimentation will be conducted and will critically reflect upon the viability of a vast range of evolving digital design tools available. The focus will prove whether the dynamic implementation of evolving tools can create complexity and richness of a design outcome through arbitrary phases of generative design methodology (Arida 2004). Designers are immersed in a digital culture of designing.

Contemporary software tools for form generation are partially being used to aid architectural design processes within the early concept and development phases in studio (Abdelmohsen 2013). However, these are limited to one or two techniques throughout the duration of architectural design projects. Enhancing this simple process with evolving techniques in a generative process implementing interconnectivity will stimulate a new excitement and era (Arida 2004), introducing innovative opportunities within all aspects of the architectural realm.

Innumerable members of the public outside of an architectural education remain somewhat unaware of the various technological advancements, able to be implemented collaboratively within an architectural design methodology (Segard et al. 2013). Software and hardware are advancing rapidly to a situation where many still believe some systems are entirely futuristic, when in fact they are now becoming a reality (Schnabel et al. 2007). Universal discussions are necessary regarding emerging technologies regarding their contribution on aiding and influencing design, especially referring to the public's involvement. Already these evolving tools are being used for the simulation and observation of virtual spaces (Maver and Alvarado 1999). However, due to software and hardware developments, interactive capabilities within immersive environments are available but limited in comparison to what they soon will be within design studios (Kvan 2001). The majority of the public sector are only aware of concept and development visualisations or animations of the final product. Considering this, it is believable that the richness and evolving digital style of a methodology ecosystem proposed within this paper is irrelevant as long as a high-quality product is produced. Thus the suggested irrelevance of an interconnective and generative architectural design process provides the opportunity for the implementation of this ecosystem of evolving design tools (Lo and Schnabel 2018). Inviting and engaging the public or client into precesses dynamically, rather than worded feedback or paper alteration sketches will be a key for success in this manner. Collaborative virtual environments within the methodology ecosystem provide a platform where this theory can occur, resulting with a new complexity and richness of an architectural design due to the enhanced engagement (Al-Qawasmi 2000).

2. Interconnective Design Methodology Ecosystem

"Many designers believe that a study of the design process will impair their ability to design", Wiggins suggests this situation from a period where CAAD was very limited and in the simplest of developments on early desktop computers (1989). Comparing this state to design tools currently available today, such as using parametric strategies, simulations and immersive environments, it would seem impossible for an architect's ability to design to become impaired. Countless tools for interpreting and translating data now exist immensely that even attempting to design for some architects could become more overwhelming regarding where to begin and deciding on the initiate tool.

Studying design processes allows the architect to explore the benefits and hindrances for certain tools (Wiggins 1989), combining the art of study and practice together provides viable inputs and outputs in order to create a successful design cycle or framework within architectural design (Schnabel 2004). Figure 1 presents the resulting framework derived from this combined research and case study with an ecosystem of dynamic interaction.

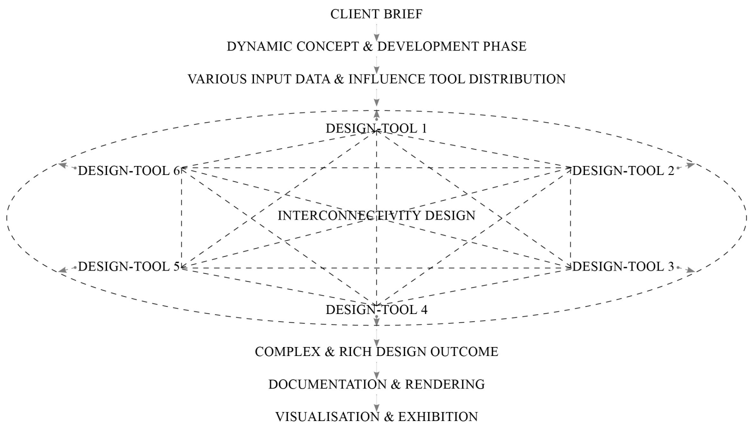

Figure 1. Proposed Interconnective Design Methodology Framework and Ecosystem.

Strategically, the key for success within this methodological ecosystem is the requirement of interconnectivity between the multiple design tools with various technological capabilities. Input data could include site and context factors, influences, and client brief, these are distributed around the ecosystem purposely or arbitrary dependent on the architect/s aspirations during any phase of the design. Generating rich and complex outputs transpires from advancing the design workflow whilst also implementing outputs from other tools simultaneously. The commencing and concluding tool must be established by any means in order to allow sufficient strength and resolution within the architectural design to come through to the end of the dynamic process.

3. Ecosystem Case Study Parameters

To provide input data for the research experiment, the selected project is a Light Rail Shelter through the center of Courtenay Place within Wellington, New Zealand. Data was composed from the site specific context, such as popular cuisine establishments and attractions, roadways, footpaths and neighboring buildings, surrounding local artistic graffiti, and the immediate neighboring building texture and form.

Tools selected for testing the proposed method are chosen due to software and hardware accessibility within studio, subjective skill ability, and what will facilitate a rich and complex outcome. These are *Quelea* agent simulations with Grasshopper. Photoshop, Rhinoceros and Grasshopper for image processing. *Autodesk ReCap Photo* Photogrammetry for a photo-scale-realistic digital site environment geometry. *Hyve-3D* for collaborative and immersive spatial sketching on a 3D movable plane with or without any site geometry. Google's *Tilt Brush* for immersive, fluid, spatial 3D digital hand sketch with or without any site geometry. *Rhinoceros 3D*, *Grasshopper 3D*, and *Fuzor* for immersive design testing, formalisation, and development. *Unity* for real-time rendering and first-person, third-person, and immersive walk-through and interactivity.

4. Agent Simulations

Commencing the interconnectivity design experiment, Quelea agent simulation tool in Grasshopper is capable of flexible autonomous path-finding within Grasshopper 3D and Rhinoceros 3D. Attractor and repellent properties were assigned to specific areas on the site plan to simulate a person's walkable path. Repellent points specify avoidance areas for example, neighbouring building and pathway boundaries. Attractor points determine pedestrian destinations of popular establishments and attractions. Using this form of site analysis to digitally simulate the movements of pedestrians within the space, generalized the population by ruling out special and extreme cases of pathways, thus producing a habitual and solid framework of pedestrians and their travel paths. To mimic this analysis by visiting the site and recording the real-time movements of the available occupants would be very time consuming and the results would vary depending on many site factors such as weather and traffic. Quelea agent simulation rules out many variables and gives complete control to the analyst (Asriana and Indraprastha 2016). The exportable path lines in any line format from Rhinoceros 3D can then be manipulated in any way to derive information to influencing the use of additional tools (Figure 2).

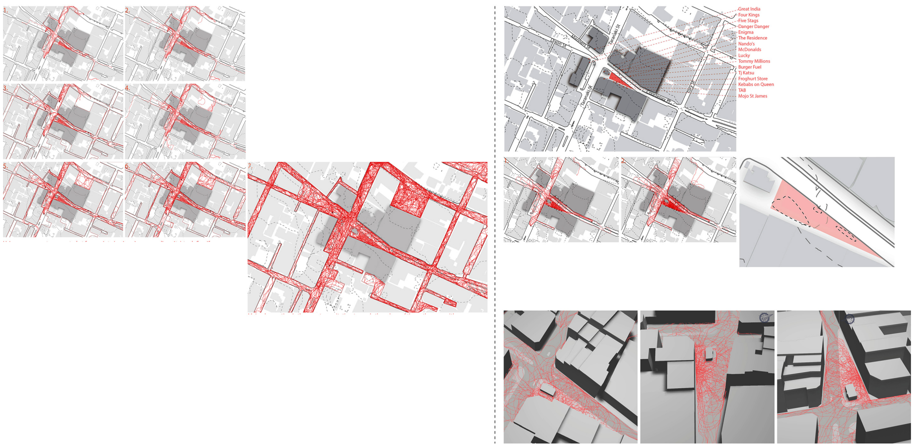

Figure 2. Quelea Agent Simulation.

5. Artistic Image Processing Analysis

Local artistic graffiti data input through *Adobe Photoshop* image sampling extracting dominant colours, contrast areas, and exaggerating shapes and shadows of the graffiti produced many abstracted outputs. These speculative products give a sense of complexity and richness throughout the process while embracing the cultural aspect and ideas behind the works of art.

An image sampling algorithm within Grasshopper 3D was then made and used to determine and triangulate points of various pixel occurrences both arbitrarily and intentionally, such as dense contrast areas and linking together nodes of similar colouration (Goldman and Zdepski 1990). These data outputs appeared very abstract, disregarding the length of control and flexibility of the algorithmic definitions, which crafted the desired complex and rich sense of working. As a result, this procedure produced a vast range of data outputs subject to interpretation (Abdelmohsen 2013), allowing a unique and near limitless range of data for the analyst to use and influence other tools by. Figure 3 shows the workflow as described above.

Figure 3. Graffiti Image Processing.

6. Realistic Site Geometry

Photogrammetry, the process of taking numerous photographs of a subject from many different angles stitched together to create a 3D piece of geometry, with realistic depth and proportions. Using Autodesk ReCap Photo, the more images acquired provides a higher quality output. In this research experiment, a digital model of the site and surrounding buildings was manipulated and used as a visual scale guide within other 3D software, and produced as an asset to implemented within other tools (Figure 4).

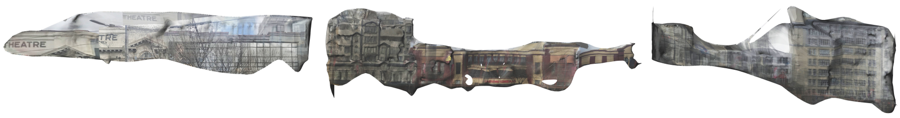

Figure 4. Courtenay Place, Wellington Photogrammetry.

7. Projected 3D Space Sketching

Three derived outputs were selected from the previous image sampling tools and developed as a form of design generation. Site photogrammetry imported into Hyve-3D created a realistic scaled environment to begin spatial form design. Agent simulation line data was also imported in the program which the sketching was referenced too, endorsing interconnectivity between tools. Here the tool also allows for a collaborative work space, increasing the range of unique interpretation to flourish between designers and client if desired (Al-Qawasmi 2000). Sketching began with reference to the previously selected outputs in the 3D environment on an iPad. The sketch is instantaneously projected onto the 3D movable plane within the 360-degree view environment, at any position, rotation, or scale personally chosen. Here this method freely translates two-dimensional data to 3D data. The generated illustrations were then exported as a 3D file format for continued use with another tool (Figure 5).

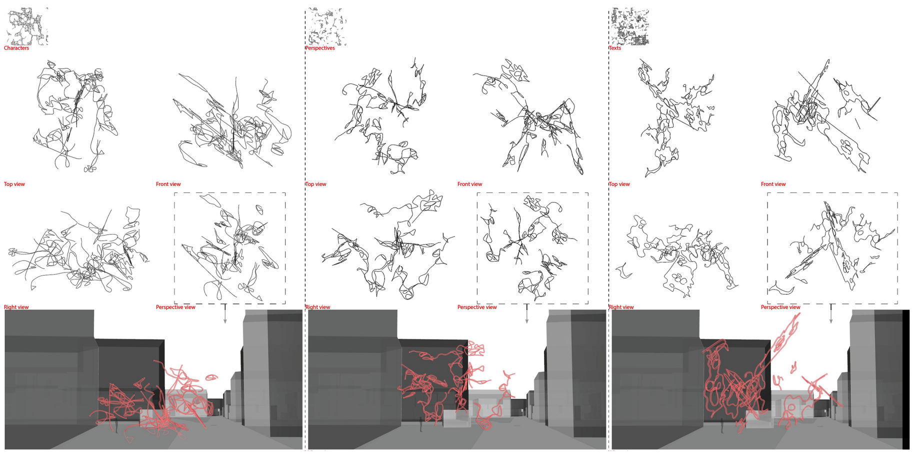

Figure 5. Hyve 3D Sketching and Rhinoceros Import.

8. Immersive Space Sketching

Google's Tilt Brush immersive virtual environment 'game' tool as a way of creating and manipulating data. A hand-controller of tools, including different style brushes, shapes, scale and settings, provided the ability of spatially generating designs 3D around the designer's body at any chosen scale. Giving complete freedom of interpretation, shaping, scale, and form production (Achten et al. 2000) it allows for a novel communication of architectural designs.

The site photogrammetry model and 3D data from multiple tools used previously were imported into the Tilt Brush program. This hub of data manipulation and creation demonstrates interconnectivity between the tools, adding a complex and rich dimension to the design process, utterly diverging away from traditional methods of paper or CAAD ‘flat screen’ design. Produced was an exportable geometry mesh with limitless scaling and alteration abilities compatible with any 3D software (Figure 6).

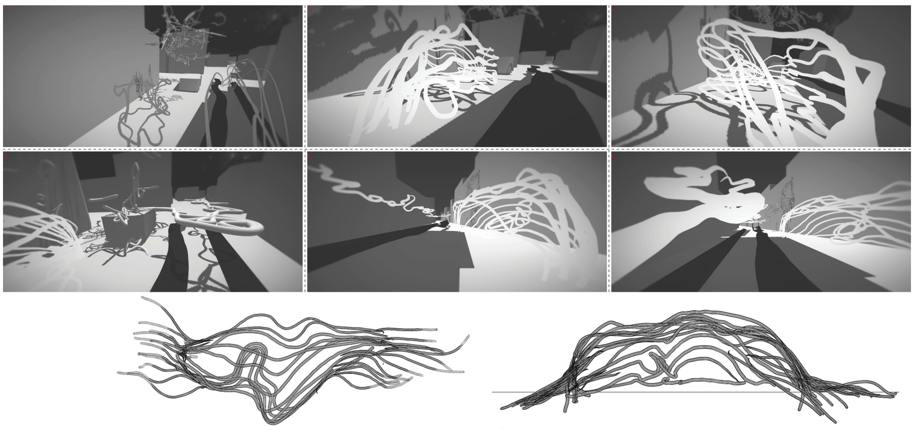

Figure 6. Google Tilt Brush Immersive Virtual Reality Sketching.

9. Rhinoceros, Grasshopper and Fuzor

Data optimisation, development, and documentation commenced within Rhinoceros and Grasshopper throughout the duration of this research methodology testing, combining all tools and working as a design hub. Imported data included the Quelea simulation path vectors, graffiti image processing outputs, site photogrammetry, Hyve 3D and Tilt Brush sketching. All developments were explored as a first-person screen walk-through, and as a 1:1 scale immersive walk-through within Fuzor testing the functionality of the design and with real-time weather data and material visualisation. 3D structural analysis then commenced supporting the validity of the tested design (Figure 7).

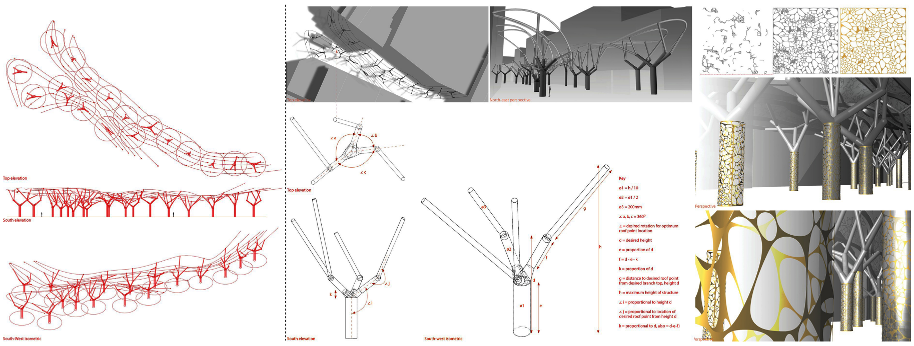

Figure 7. Rhinoceros and Grasshopper Parametric Design of Column Placement and Lattice Design.

10. Immersive Working Presentation

The working outcome resulting from the proposed interconnectivity design process within a realistic immersive environment was exhibited within Unity as an .exe file. This tool simulated the design formally working as-built in a day and night cycle with site-specific weather patterns (Petric 2001). Rather than presenting mere flat-screen renderings with a positioned human figure for scale, the exhibition participant or experienced the design in full functionality and its impact within the space regarding all design aspects. Here options exist to further develop the design itself or to build (Figure 8).

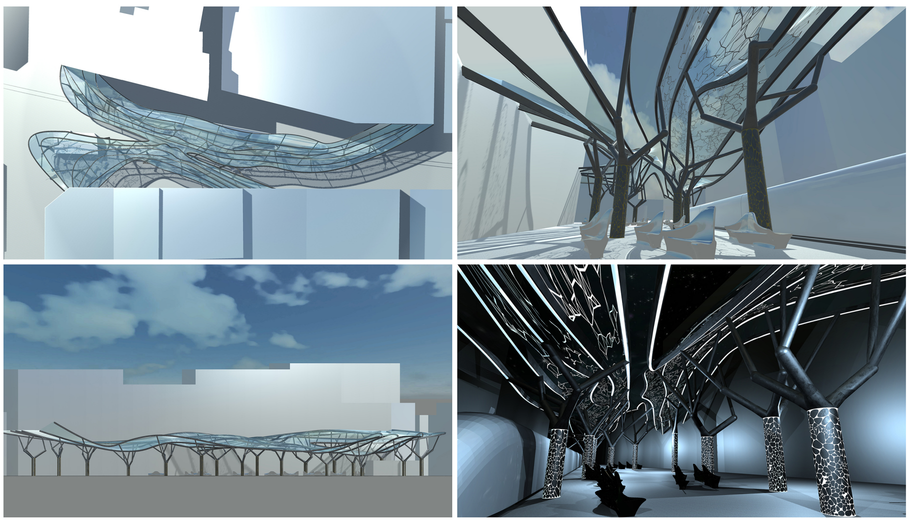

Figure 8. Orthographic and Perspective Views Real-time Rendered in Unity.

11. Conclusion

Interconnective methodology ecosystem using the range of evolving digital tools in a generative way within this architectural design research proved very successful. All design inputs were strategically organised, processed and thus converted to form an intricate outcome. These unique and complex forms have visual and numerical reference to all the input data thus enriching the outcome with complexity. Figure 9 shows an overview of how the design methods interconnect in the here presented ecosystem and how they form a digital culture in architectural designing.

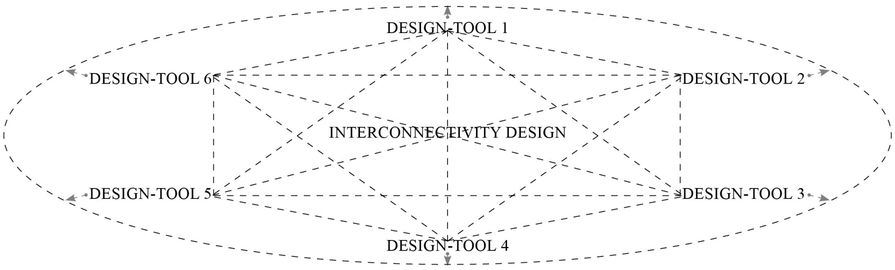

Figure 9. Interconnective Design Methodology Ecosystem.

"While a designer may have a good tacit justification for his or her design work, finding the words to express the justification may be very difficult" states Wiggins (1989). This research paper's methodology bypasses these doubts Wiggins suggests that a designer may acquire, as the processed inputs speak for themselves as data outputs, the method always remains clear and concise. As the option exists within the framework to revert back to a singular point within the ecosystem and alter the design direction, the interconnectivity and dynamic style of the methodology allows this flexibility to exist.

The dynamic implementation of evolving tools created the desired complexity and richness of the design outcome through all phases of the generative design ecosystem. Typically design tools are treated as separate entities for different data inputs, this does not need to be so. The proposed methodology diagram treats the tools as an ecosystem of interaction, that the design cannot be as complete without them all working as a combination. Each selected design tool is an essential ingredient within the ecosystem. Every selected tool will always have its own strengths and weaknesses regarding the capabilities of both the designer and the tool. The differing nature of each design tool allows the designer to generate outputs that makes use of properties and functions another tool might fail to offer.

This research paper deriving the validity of the interconnective design methodology ecosystem advanced the traditional method of design from paper sketching, CAAD works, and standard 'flat screen' rendering. This framework embraces a digital culture in which designers are immersed and that revolves around digital technologies in a generative way across a wide range of techniques resulting in a vast field of opportunities. Enhancing processes such as this stimulates new excitement for all designers, clients, and the public by implementing innovative procedures singularly and collaboratively to invoke new experiences and definitions of architectural designs.

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