Performative Architectural Practice

Building Collaboration Platforms for Multidisciplinary Architecture Business

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***Abstract*— The last decade in architectural practice has witnessed a significant shift in our understanding and use of digital tools. The most significant recent development in the field of architecture is the realization that software processes aren't simply tools designed by software developers - they can become the very material from which designs are made. New design disciplines like interaction design, robotics, smart facades, data-driven design and artificial intelligence are evolving design practice to a module that is more agile, collaborative and project-idea centred. Fuelled by emergent technology and the application of computational processes to design problems, emergent design practices have reintroduced performance as a creative driver. These new generation practices are developing business modules that prioritise intelligent 'building matrixes' as an avenue through which to achieve design solutions that are based on scientific research.**

This paper discusses the changing landscape of architectural practice, the introduction of new design disciplines into architectural practice, and the emergence of multidisciplinary architecture business models that are based on design performance. Through a series of case study examples, this paper examines recent advancements in performance-based computation, and how the use of Computational Design and emergent technologies are enabling, and driving, innovations in architectural practice.

Keywords—Innovation; Architectural Practice Futures; Data-driven Design; Computational Design

I. Introduction

A. *Design in 21st Century : From Idea Provider to Solution Provider*

Architecture is currently experiencing a paradigm shift in the process and conceptualisation of design and professional practice. Fuelled by the introduction of technology into the design process, the architectural profession is seeing the emergence of innovative models of interdisciplinary and collaborative practice that merge generative design and emergent computational processes with experimentation and research (Long, 2016; Moser, 2013). The shift towards parametric data-driven modelling processes and the involvement of smart technology in design processes don't deny the role of the architect, nor devalue traditional praxis. Rather, it offers new modes of multi-disciplinary and collaborative practice centred on performance-based computational frameworks that allow for rapid feedback and testing of design iterations (Chaszar & Joyce, 2016).

Emergent technology such as artificial intelligence, generative design processes, smart technology, data-driven design, augmented reality, and sensing technology are rapidly developing and changing the business models, the types of new start-ups, and product and service development across a range of industries. Within architecture, these rapidly shifting technological innovations are having a profound effect on the architectural industry - modifying architectural service provision typologies, modes, practices and products. Within this morphing practice landscape, we see a shift away from the conceptualisation of design-as-idea provision to one of design-as-solution provision.

This hybrid practice model places an emphasis on multidisciplinary collaborative experimentation and research that moves beyond basic solution driven outcomes and pushes the boundaries of traditional design confines. The introduction of computational design processes and the availability of big data, have enabled transformations in design processes and outcomes. The ability to utilize live and/ or static data to inform the design process, in conjunction with the capacity for iterative and rapid computational design processing, have enabled data-driven design processes that are premised upon the concept of design-as-solution. This has resulted in the ability for practices to move beyond an approach that focuses on a limited design-as-ideas approach, to one in which we see the provision of design-as-solution through the transformation a data driven ideas process and data-informed computational design.

In his book, Architecture 3.0: The Disruptive Design Practice Handbook, Cliff Moser outlines an emerging trend within the architectural profession in which architectural practice is moving towards a model centred around solution provision rather than building design. According to Moser, this paradigm shift was instigated by the global financial crisis of 2008 and the subsequent downturn within the construction industry (Moser, 2013). The sudden financial downturn left in its wake a volatile and highly competitive market, which, in conjunction with a growing perception of architecture as an industry that had "overspecialized, under-delivered, and […] served no purpose" (Moser, 2013, p.1), forced practices to re-examine the purposes, modes and models of architectural praxis. Tethered by the "vestigial legacy" (Moser, 2013, p.2) of traditional professional roles, contractual relationships, and modes of production, architects had to radically re-think practice typology.

Centred around a series of case studies, this paper looks at the shifting terrain of architectural practice, and the impact of technological innovation on the architectural profession. Through an examination of emergent modes of practice, this paper examines how technology based workflows can be implemented within practice to facilitate and promote building performance as a driver for change.

B. Design with Data: Information/Data Driven Design

Developments such as the Internet of Things (IoT), a network of devices that collect and exchange data, are providing new opportunities for the architecture, engineering and construction industries. Whilst within contemporary practice designers have been using data to inform the design process, for the most part, this is structured as a value-add process in which in-built assumptions and parameters define a data-enabled/enriched design outcome (Deutsch, 2015). A common example of such processes is the use of weather data to assist in compliance with solar access requirements for residential design. Within the state of NSW in Australia, section 4A of the State Environmental Planning Policy No65 (SEPP65, 2015) sets out design guidelines, objectives and criteria for solar and daylight access within residential apartment developments. Utilising local weather data, designers are able use data-enabled parametric design processes to set solar access values and parameters to modify building orientation, building fenestration and design solar shading devices so as to comply with SEPP 65 guidelines. Whilst such processes enable designers to run a large number of models and iterative design variables that would traditionally not have been feasible due to their complexity and labour intensive requirements, outcomes are limited by in-built assumptions and parameters that are pre-set at the outset, or heavily value based.

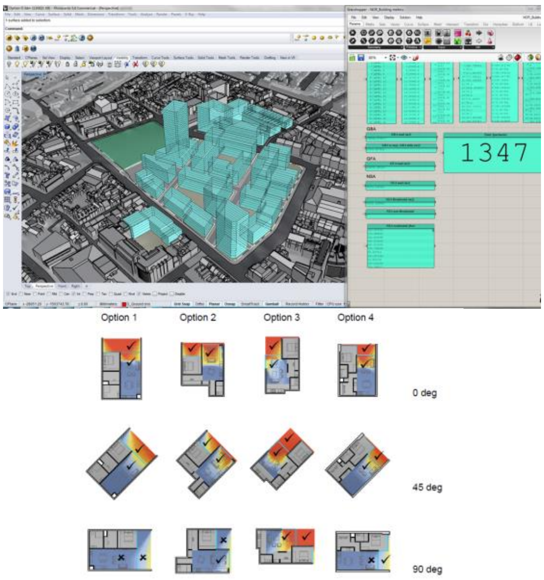

Fig. 1. Sepp 65 residential development script which account for code requirements - developed at BVN Architecture in Sydney

Data-enabled design processes such as the one described above, typically utilize existing and known data, and do not allow for a truly responsive design process. Data is subordinate within this design process, creating a data-enabled (notional) rather than data-driven (responsive) systems process. This restricted application of computational design processes is one that is highlighted by Deutsch as a current limitation within the architectural industry (Deutsch, 2015). Deutsch claims that architectural practices could learn from the gaming industry as well as pioneering IT companies (such as Apple and Google) that have created data rich and responsive design processes. One example of the way in which emergent gaming developments have been adopted for design applications is in the development by AECOM of the Sustainable Systems Integration Model (SSIM). AECOM's system, adapts a data-driven decision making capacity to a modelling system that creates a data-rich and immersive environment with which to run comparative testing simulations for urban planning (AECOM; ElectronicArtsInc., 2014). SSIM allows designers, clients and the public to generate multiple development alternatives and understand the environmental and financial consequences when parameters are varied. Advancements in gaming technology have enabled a rich complexity of urban planning decision feedback processes and predictions. SimCity for example, is able to deliver an unprecedented depth of simulation by allowing for multi-dimension design decisions - where by decisions and design changes that you make on a city that you have designed within the game, impact on both the individual player city and the region. This "butterfly effect" which was embedded in the game script, has the potential to enable players and architects, if the same strategy is implemented in architecture CAD programs, to explore and test the implications of design decisions through modelling and simulations within data-driven habitats.

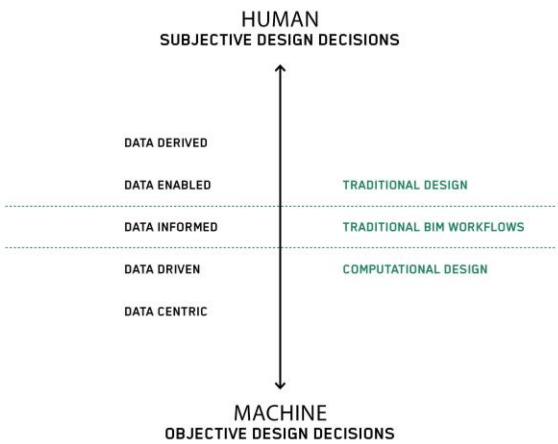

Fig. 2. Types of data versus design methodology. (Adapted from Deutsch, 2015)

Big Data is providing a new paradigm for design. In his book, The Architecture of information: Architecture, interaction design and the patterning of digital information, Dada-Robertson claims that the spatial patterns which we make in our environment are a primary means of human communication" (2011, p. 144). According to Dada-Robertson, "information only becomes relevant once it is linked to action", and it is only through the "shaping of our experience of space and influencing our behaviours, [that] computational information acts as an intermediary between place and action and software becomes as 'architectural' as its more traditional 'hardware' counterparts" (p.144).

In simple terms, IoT is modifying the way we think about design, and contributing to a scenario in which design is driven by a process of information production, capture and synthesis that is embedded in, and feeds back into, the design process. Within this scenario, architects are designing for the behaviour of their designs, which are in turn influenced by the data captured and analysed within the design process. The emergence of such processes provides the ability for designers to create smart buildings (or building parts) that are able to adapt to serve real-time performance needs. One example of this is the development of smart cities initiatives that are based on the integration of information and communication technology, real-time sensors, data collection and monitoring. These initiatives provide the ability to develop data-driven design and management solutions across a range of scales, from discrete site based solutions to large urban data-driven solutions. Technology based providers such as IBM and Cisco have taken a leading role in driving the business of smart cities through the design, development and delivery of smart-technological innovations. However, within the technology implemented workflow which these companies currently provide, design does not necessarily serve as the primary driver for data-centric solutions and service provision.

The aforementioned processes challenge the current ways in which we approach Building Information Modelling (BIM). Through the inclusion of integrated data-rich computational systems within design processes, such systems function not only as a tool for documentation or design, but also as a platform with which to produce data-responsive and dynamic designs. Within these models, the dynamic feedback system serves as a design driver (such as performative design, kinetic design, interactive design and smart design), and creates a platform for real-time inputs, analysis and iterative design testing. Through the design and real-time building feedback process, such systems provide the potential to translate models such as Facility Management (FM) Models into a live system similar to SimCity; enabling the end user to access and modify design and performance parameters based on feedback data. This information, if connected with Rich Data that is synthesized from Big Data processors in real-time, provides the potential to turn the building into a smart object that is able to inform the user of the current building behaviour and predict future building behaviour.

II. Redefining Innovation in The Design Industry

A. *Current architectural practice: the design technology dilemma*

Within many architectural practices, the position of BIM manager is structured as a technical role, the function of which is to provide support to the design team. Typically, within large scale architectural practices, technology teams are separate from design teams. This separation, or siloing of knowledge and certain aspects of the practice base, has led to an industry wide situation in which design teams may not be fully equipped to perform certain design tasks. The rapidly expanding introduction of new technology into architectural practice is resulting in an ever expanding knowledge gap within the industry - creating a schism between those who function in a technology-centric role and those who operate in a design-centric role within practice. However, an awareness of the ramifications of this schism, and its impact on practice models and the efficacy of design teams is only just starting to emerge. Few architectural practices to date are working to address this schism and develop a design technology team who is able to implement design software-tools and drive innovation in architecture practices.

B. *Technology to drive innovation: Computational design introduction to the industry*

Continuing technological advances and developments in Computational Design have opened up a range of new design processes and opportunities for architects, allowing designers to develop software tools tailored for specific design processes and applications. When based on real data, the development of these tools enables data-driven design processes and opens up new avenues for the production of creative outcomes (Davis, 2015). Within this shifting paradigm, architectural practice shifts away from business models focused around a design idea-centric service provision to one that is a design solution-centric service provision model. Within Australia, one example of where this is happening is at BVN Architecture, where computation is being used as a driver for innovation in design within the practice. BVN's strong focus on building performance metrics, has enabled them to implement data-rich computational design processes, and test and develop designs based on environmental, social, and experiential metrics.

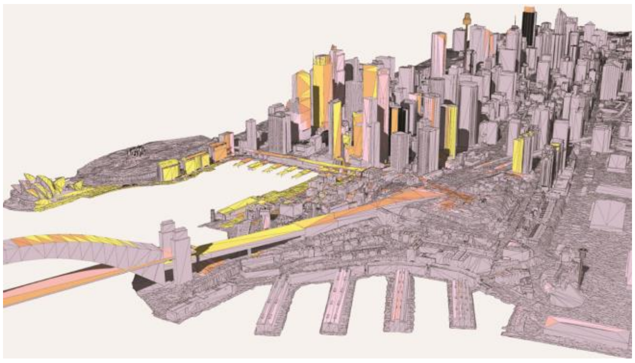

Fig. 3. Viewshed Analysis – Syndey City Wide View Analysis using Automated List Processing in Grasshopper, Rhino 3D

Within architectural practice, computational design also has the ability to be used as a learning platform, facilitating knowledge acquisition about the impact of aspects such as environmental, statutory, and social requirements through a modelling-test-feedback loop script process. This process allows users to see and test the impact of parameter changes on the design, and develop a better understanding of the complex interplay of factors that impact on design processes, performance and outcomes. For example, a script developed for a commercial tower complex, has the potential to facilitate continuing professional learning on issues such as requirements for Premium or Class-A office buildings through the feedback it provides when parameters are changed.

Computational design is facilitating multilevel innovation within architecture practice, fuelling the development and implementation of new technologies and enabling the application and expansion of R&D within architecture practice. Whilst the research and development capacity of computational design systems has, to date, had limited uptake within sections of the architectural industry, practices and research institutions such as those of Carlo Ratti and the MIT Media lab are embracing the R&D potentials of computational design. Through the incorporation of sensing technology within the design process, Carlo Ratti has created a hybrid computational design-theory-research practice approach that embraces the potential of technology to change the way we understand, design and ultimately live in cities (Ratti & Claudel, 2015). At the MIT Media lab, the focus is on technology as a driver for multidisciplinary collaboration and innovation. The model employed at MIT utilises a design through technology process coupled with the convergence of multidisciplinary teams in technology, multimedia, sciences, art and design, to promote innovative design research and development.

III. Business Approach for The New Design Era

In 1965, the cofounder of Intel and Fairchild Semiconductor, wrote a paper which outlined the exponential increase in technological component complexity over time (Lopes, Tenreiro Machado, & Galhano, 2016). This mathematical description of the relationship of technological progress to time, came to be known as Moore's Law. With the strong role of technology within architectural practice and production modes, this exponential growth in technological and machine capacity has a profound potential for flow on impacts on innovation and developments within the architectural industry – a potential that is at present under-realised.

With the rapid pace of technological developments, the 21st century economy transforms information into products, processes, and services that fuel economic growth, and create employment and wealth at an ever increasing pace (Case, 2016). This has created the situation in which design has become a hybrid platform where science, programming, technology and design are emerging as one. To thrive within this context, practices need to look at ways in which to:

1- Focus on investing in the development and enrichment of the expertise contained within their teams,

2- Experiment with entrepreneurial business models, and

3- Structure their work place practice models so that they promote and are inclusive of interdisciplinary skills sets and a more diverse knowledge base.

IV. Performance Based Computation Through Design Case Studies

A. *Multidisciplinary Bottom-up Implementation Approaches in Solution Computing: Redefining Multi Disciplinary Teams*

During the last decade, many of the large scale architecture practices have started developing their own tools and investing in R&D to allow for a greater in-house computational design capacity. This has enabled designers to craft their design tools to suit their own project and R&D needs (Davis, 2015). Exploratory projects are utilised as a mechanism by which to enable designers to implement computer science processes to solve design challenges. While such processes have succeeded in enabling faster resolution of discrete problems such as solar access and form finding, their application to whole-of-design generation approaches is still limited. An exception to this is Gehry Technologies, a practice that has merged tool creation and design generation to create an innovative and evolving practice model that interlaces interdisciplinary technological developments with research, design and innovation.

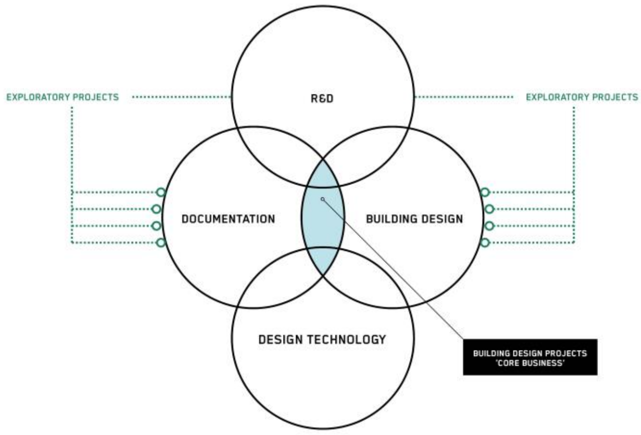

Fig. 4. Traditional architecture business model based on building design

B. *New design discipline START UPS : Pilot research projects*

In the current data-driven design era, we are witnessing a shift in the roles, skill sets and knowledge base of those involved in design processes. Increasingly, multidisciplinary teams are required to design and deliver new projects. Business models based around the creation of integrated solutions require integrated interdisciplinary teams that may be comprised of quite diverse members such as data analysts, programmers, IoT experts, artists and designers. In this shifting landscape of emerging hybrid practices, architectural businesses need to re-think the types of roles, and skill set mix of their staff if they want to remain competitive.

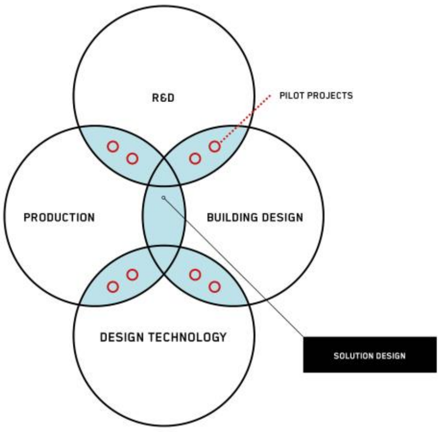

Fig. 5. Business model based on solution based architectural practice

Solution driven design strategies can be developed within practice as part of the architectural business model if they are coupled with applied pilot projects that engage multidisciplinary research teams and serve as a testing ground for the implementation of innovative design processes. Within this context, the practice workspace serves as a research lab for the testing of new ideas, materials, designs and practice modes. At BVN, an Australian based firm, the research team has invested in a one year study to investigate the potential to incorporate robotics into their design process. Within their research, BVN are examining how robotics can be used to improve design processes and business workflows through:

1. The utilization of the 6 axis robot arm tool to produce designs that enable the creation of more flexible morphologies (such as kinetic ceilings);

2. Product exploration and development into areas such as streamlined production processes, and novel materials research and applications.

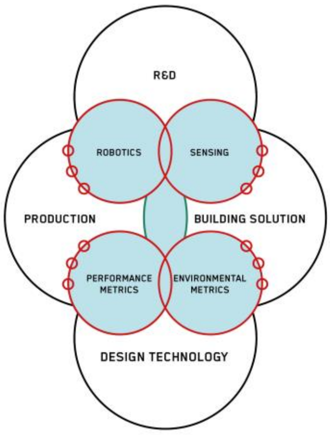

Fig. 6. Future architecture business model based on the development of extended business disciplines (in sensing, robotics and performance based design) within architectural practice

C. Internal and External Collaboration Modules: Creating a Business Community of Technology Driven Change

The ability for practices to engage in pilot research projects, start-ups, and interdisciplinary collaborative processes, has been greatly facilitated by the development of collaborative platforms. Over the last five years, the ability to design for solutions has increased due to the effective use of collaboration platforms such as Slack (real time communication messaging), Newforma (software that manages project information using multiple apps, enabling architects to access all project files from anywhere), Trello (collaborative tracking of project task lists) and Citrix (a cloud based computing server established to maximize collaboration).

With advances in technology, there is a strong need for business to educate industry of the advancement in order to effect change within business as a whole (Dade-Robertson, 2011). Through the sharing of ideas and the promotion of an interdisciplinary dialogue about innovation, the architectural industry can connect with and capitalise from research and developments that are taking place across a range of different sectors. One example of a forum facilitating this dialogue and knowledge exchange is the Sydney Computational Design Group, a forum that invites international guest speakers to present on cutting edge technological developments, research and innovative practices to wide range of audience members such as builders, engineers, planners, programmers and architects (SCDG).

Fig. 7. View analysis based on contextual data gathered from Circular Quay, Sydney by 3XN and BVN

V. Discussion and Future Experiments

With continual technological advances, research and development is an important part of the practice base for any firm. Fuelled by emergent technology and the application of computational processes to design problems, to be competitive, emergent design practices have to reintroduce performance as a creative driver and instigator of change. The shift towards data-driven design is necessary one, if practices are to achieve responsive workflows and create innovative solutions. Technological innovations, Big Data availability and the rise of the IoT, have enabled firms to adopt solution driven creative design processes. New generation practices are developing business modules that prioritise intelligent 'building matrixes' (multi-dimensional rich-data sets that drive design) as an avenue through which to achieve design solutions that are based on scientific research and data synthesis. These multidisciplinary business models are based on design performance, and enable the development of data-rich solutions based design processes. The introduction of new design disciplines into architectural practice is a must in order to thrive during this 'smart' era in which the ubiquity of technology mandates diverse interdisciplinary design teams in order to facilitate the translation from speculative R&D to product development.

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