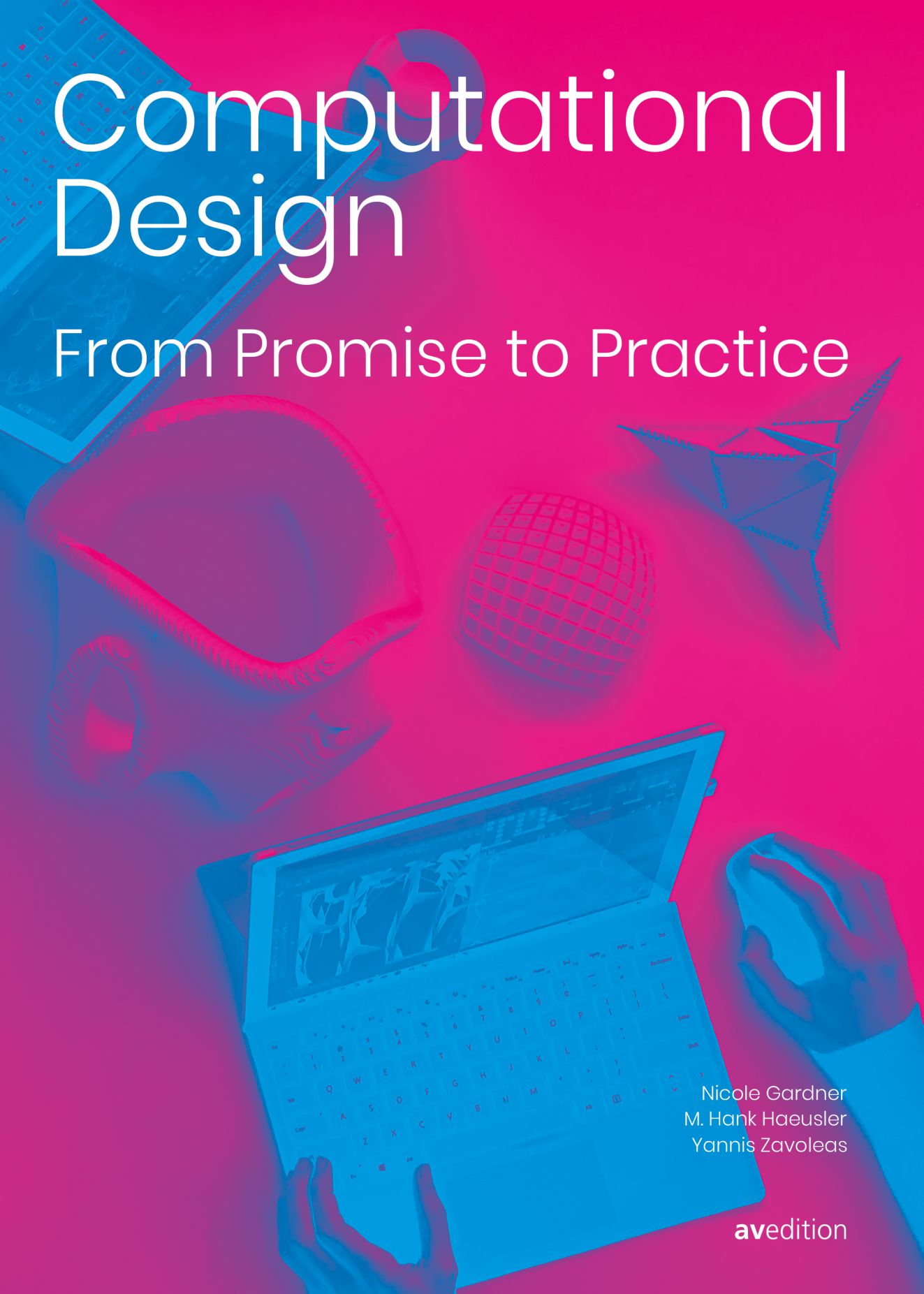
Computational Design

From Promise to Practice



Nicole Gardner
M. Hank Haeusler
Yannis Zavoleas

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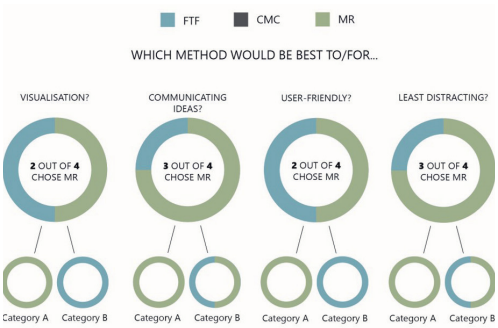
HOLOSYNC:
A Comparative Study on Mixed Reality and Contemporary Communication Methods in a Building Design Context

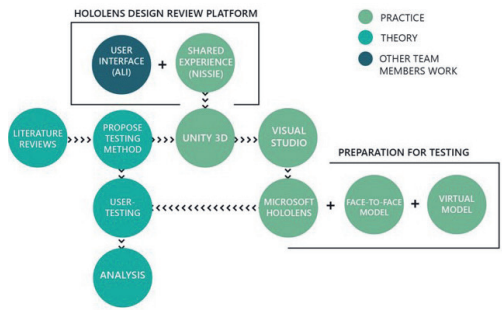
Narissa Bungbrakearti,
Ben Cooper-Wooley,
Jorke Odolphi,
Ben Doherty,
Alessandra Fabbri,
Nicole Gardner and
M. Hank Haeusler

Keywords.
Dynamic Simulation; Data-Driven Design; Multi-Agent Systems; Computational Tools.

Industry Partner.
ARUP Sydney

The integration of technology into the design process has enabled us to communicate through various modes of virtuality, while more traditional face-to-face collaborations are becoming less frequent, specifically for large scale companies. Both modes of communication have benefits and disadvantages - virtual communication enables us to connect over large distances, however can often lead to miscommunication, while face-to-face communication builds stronger relationship, however may be problematic for geographically dispersed teams. Mixed Reality is argued to be a hybrid of face-to-face and virtual communication, and is yet to be integrated into the building design process. Despite its current limitations, such as field of view, Mixed Reality is an effective tool that generates high levels of nonverbal and verbal communication, and encourages a high and equal level of participation in comparison to virtual and face-to-face communication. Being a powerful communication tool for complex visualisations, it would be best implemented in the later stages of the building design process where teams can present designs to clients or where multiple designers can collaborate over final details.





Post-test survey and Holosync workflow © Narissa Bungbrakearti

This paper was first published in: Learning, Adapting and Prototyping - Proceedings of the 23rd CAADRIA Conference - Volume 1, Tsinghua University, Beijing, China, 17-19 May 2018, pp. 401-410

Scan QR code to read

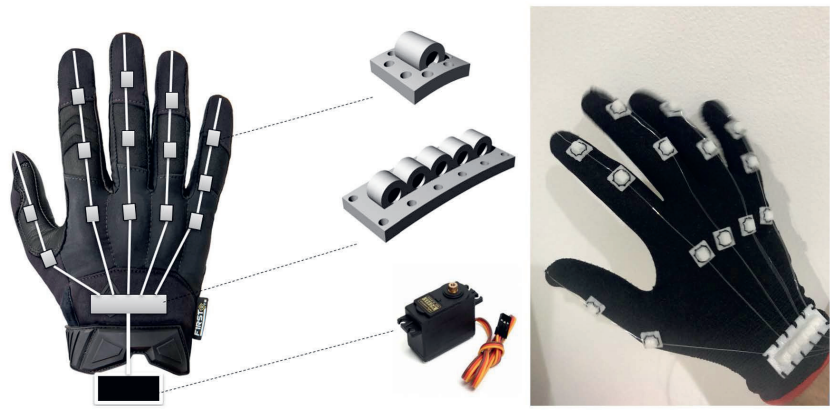
Hands On Design: Integrating Haptic Interaction and Feedback in Virtual Environments for Enhanced Immersive Experiences in Design Practice

Daniel Camacho,
Tiara Dobbs,
Alessandra Fabbri,
Nicole Gardner,
M. Hank Haeusler and
Yannis Zavoleas

Keywords.
Virtual Environments; Haptic Technologies; Feedback; Interaction; Usability

Industry Partner.
PTW Sydney

The usability of virtual reality (VR) controller interfaces are often complex and difficult for first time users. Most controllers provide minimal feedback which relegates the potential for heightened interaction and feedback within virtual experiences. This research explores how haptic technology systems partnered with VR can deliver immersive interactions between user and virtual environment (VE). This research involves the development of a haptic glove interface prototype that incorporates a force feedback and vibrotactile feedback system. It focuses on determining a workflow that communicates in real-time user interaction and environmental feedback using Unreal Engine and the produced haptic glove system. Testing and calibrating the prototype feedback system provided a baseline for developers to rationalise and improve accuracy of current real-time virtual feedback systems. The evaluation of this research in industry unfolds new technical knowledge for implementing a wider range of haptic technologies within VR. This further development would involve reviewing the usability and interaction standards for VR users in the design process.



Force feedback channel mechanism design and prototype © Daniel Camacho

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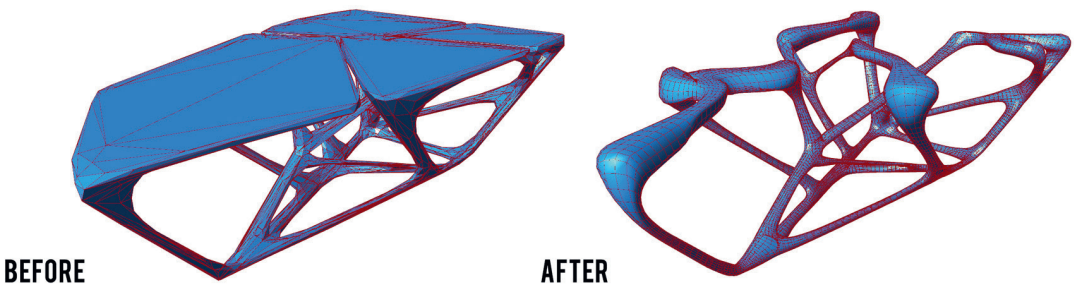
Streamlining the Modelling to Virtual Reality Process

Lachlan Sharah,
Erik Escalante,
Alessandra Fabbri,
Romain Guillot and
M. Hank Haeusler

Keywords.
Virtual Reality; Quadrangulation;
UV unwrapping; Physics Simulation.

Industry Partner.
Grimshaw Sydney.

Visualisation in architecture often involves a transition between different modelling programs. This is done in order to be able to manually prepare and repair three-dimensional models for visualisations such as renders and VR simulations. In this paper the development of a direct link between a three-dimensional modelling platform and a Virtual Reality (VR) Engine is investigated. This is researched through the generation and manipulation of clean quad mesh topology, UV mapping and UV texture map creation. Through a reiterative process, all possible solutions for improved quad mesh topology for doubly curved surfaces are explored. The resulting clean quad mesh improves the usability of the model and application of textures to accurately simulate a real material. In parallel, the development of a UV unwrapping and UV map creation process was investigated to enhance the texturing process inside the same architectural modelling platform. The overall system was developed as an advanced tool for semi-automating and streamlining the process between modelling and VR simulation. The paper concludes with the limitations of the process and points out to future research to improve speed and quality as well guides to where future testing and experiments should be further investigated and applied.



Quadrangulation of the Mesa Table by Zaha Hadid using the Inflation Method. © Lachlan Sharah

This paper was first published in: Protocols, Flows, and Glitches - Proceedings of the 22nd CAADRIA Conference, Xi'an Jiaotong-Liverpool University, Suzhou, China, 5-8 April 2017, pp. 53-62.

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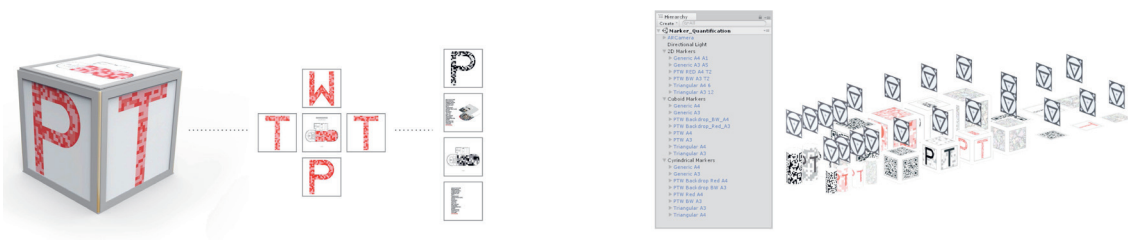
Augmented Reality in the Design Process: Using Visual Effects (VFX) Motion Tracking techniques to Conduct Research on the Performance of Augmented Reality

Harris Paneras,
Michael Yip,
Tiara Dobbs,
Ben Doherty,
Alessandra Fabbri,
Nicole Gardner and
M. Hank Haeusler

The research explores how quantitative performance analysis of augmented reality would influence its mainstream adoption within the Built Environment Industry. The process involves the development and quantification of key augmented reality components, through the use of Visual Inertial Odometry and Visual Effects motion tracking techniques. Targeting mobile technology as a case study for the research, its potentials and limitations will be explored and discovered in relation to the industry. Accordingly, the research focuses on assessing the visuality and communicative quality of augmented reality projections from 2D, cuboid, cylindrical, 3D object, geo-location and marker less. Testing this form of technology under realistic scenarios provides a baseline for developers to rationalise their choices in their augmented reality development. This would study the effectiveness of augmented reality projections and vindicate the typical constants and variables when developing augmented reality applications, reducing the need for ongoing practical experimentations to successfully achieve augmentation.

Keywords.
Mobile; Augmented Reality; Performance Analysis; Fundamental Research; Quantitative Research.

Industry Partner.
PTW Sydney



Cuboid physical prototype with active markers slotted inside (left). Unity hierarchy setup with the VFX marker in place within the single scene. © Harris Paneras

Kepczynska-Walczak, A, Bialkowski, S (eds.), Computing for a better tomorrow - Proceedings of the 36th eCAADe Conference - Volume 2, Lodz University of Technology, Lodz, Poland, 19-21 September 2018, pp. 761-770

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Enabling Low Cost Human Presence Tracking

Annisa R. Rizal,
Ben Doherty and
M. Hank Haeusler

Keywords.
Movement Tracking; Workplace Environment; Wireless.

Industry Partner.
BVN Sydney

Finding automated methods to track the presence of humans can help designers understand workplaces. Methods to understand the patterns of human movement in workplaces using beacons, badges and sensors are being developed. Whilst the results are promising, they can be costly and may require the manual setup of expensive equipment. The Global Positioning System (GPS) is widely adopted due to its high degree of accuracy, however, is inapplicable in indoor environments due to the physical limitations of satellite attenuation. There is no comparably ubiquitous positioning system that can be used to make device-driven position tracking that is specifically adapted to indoor environments. With the increasing popularity of phones, watches and fitness tracking bands with WiFi and Bluetooth connectivity, we explore the potential of these wireless radios as a low-cost alternative to monitor human movement. As the costs of technology continue to decrease, the means to build a low-cost tracker through WiFi and Bluetooth enabled devices in an indoor environment become possible. Furthermore, is it possible to develop a low-cost tracking device using only commodity hardware that is able to accurately automate and record presence in space with sufficient veracity?

Low cost human presence tracking © Annisa R. Rizal

This paper was first published in: Living Systems and Micro-Utopias: Towards Continuous Designing, Proceedings of the 21st International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2016)/Melbourne 30 March–2 April 2016, pp. 45-54

Scan QR code to read

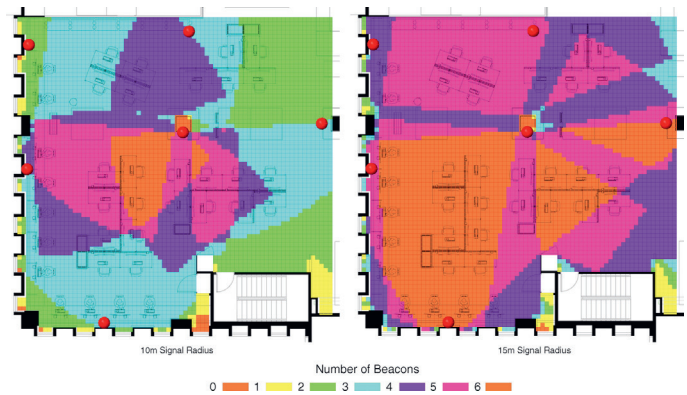
Discoverable Desks: Finding Location and Orientation in a Mobile Workplace

Sophie Scott,
Ben Doherty,
Alessandra Fabbri,
Nicole Gardner and
M. Hank Haeusler

Keywords.
Indoor Positioning Systems; Office Space Planning; Location Data; Computer vision; Activity-Based Working

Industry Partner.
BVN Sydney

The drive towards increasing productivity through collaborative ways of working has spurred a parallel trend in flexible and adaptable workplace environments. Mobile desks are one feasible solution to this but workplaces that adopt mobile desks risk creating spatial inefficiencies. These range from overcrowding or underutilization, to potential compliance issues in terms of fire egress requirements and health and safety regulations. While there is a need to understand mobile desking configurations there are currently no well-established ways to track the location and orientation of mobile desks within workplaces. Consequently, this paper describes a research project that adopts an action research methodology as an iterative and participatory framework to investigate and develop a unique method for capturing the location and orientation of freely moveable desks in an open workplace environment. This uses an ensemble of Bluetooth location beacons and computer vision techniques to provide a finer resolution than either method alone can currently provide. The demonstration of this ensemble method is the main contribution of this work. This paper demonstrates that combining these methods can enhance the advantages of each; computer vision gives higher resolution and beacons reduce the scope of the image search task.



Beacon signal diagram © Sophie Scott

This paper was first published in: M. Haeusler, M. A. Schnabel, T. Fukuda (eds.), Intelligent & Informed - Proceedings of the 24th CAADRIA Conference - Volume 2, Victoria University of Wellington, Wellington, New Zealand, 15-18 April 2019, pp. 653-662

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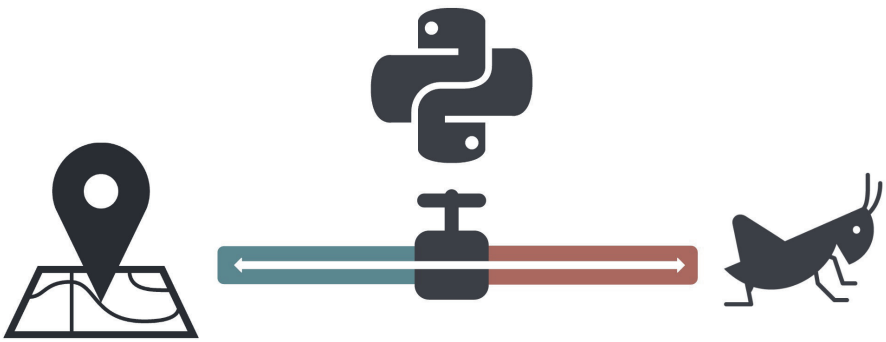
Urban Pinboard: Establishing a Bi-directional Workflow Between Web-based Platforms and Computational Tools

Madeleine Johanson,
Nazmul Khan,
Rob Asher,
Andrew Butler and
M. Hank Haeusler

Keywords.
Urban Planning; Computational Urbanism; Data-driven Design; New Workflow Models; Software Development.

Industry Partner.
Cox Architecture Sydney

Architecture is heading towards a future where data is collected, collated and presented in a dynamic platform. There is a potential for many standard processes in the industry to become automated, such as the site analysis process. Streamlining aspects of the design process allows architects to pay greater attention on creative design solutions for their buildings and less time engaging in complex, time consuming analytical programs. Urban Pinboard, a web-based GIS platform, promises to establish a bi-directional workflow between web data depositories and computational tools through the medium of a website. By doing so, the website allows users with minimal experience in computational processes to be engaged in the utilisation of these large datasets. Through the automation of these processes, relationships within the built environment industry can excel, leading towards performative driven designs.



A diagrammatic representation of the bi-directional pipe, connecting web-based data depositories and Grasshopper. © Madeleine Johanson & Nazmul Khan.

This paper was first published in: P. Janssen, P. Loh, A. Raonic, M. A. Schnabel (eds.), Protocols, Flows, and Glitches - Proceedings of the 22nd CAADRIA Conference, Xi'an Jiaotong-Liverpool University, Suzhou, China, 5-8 April 2017, pp. 715-724

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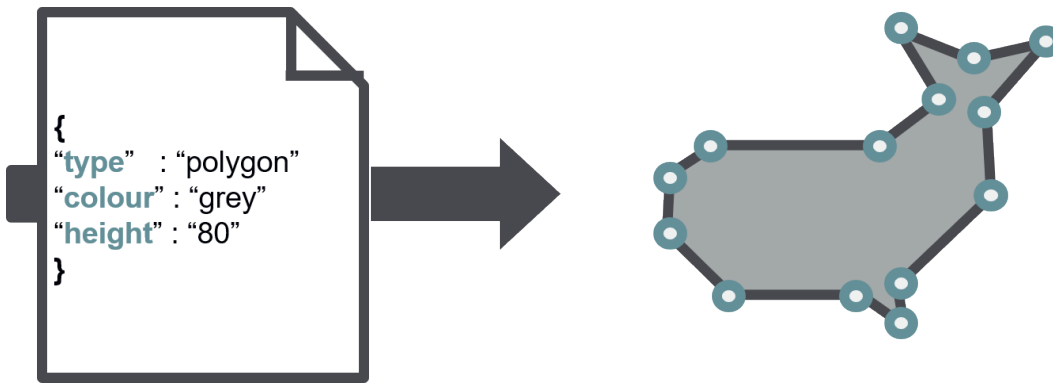
HUMPBACK: Introducing and Evaluating a GeoJSON Constructor Tool for Grasshopper

Madeleine Johanson,
Nazmul Khan,
Rob Asher,
Ben Doherty and
M. Hank Haeusler

Keywords.
Urban Planning; Computational Design; Geographic Information Systems; Design Tool; Open Format.

Industry Partner.
Cox Architecture Sydney

This paper presents Humpback, a plugin for the computational tool Grasshopper. In our background research we identified that due to limited workflow connection between Geographical Information Systems (GIS) and computational design tools, a gap of informed urban design outcomes exists. Humpback extends Grasshoppers capability to read and write GeoJSON; a geographic data format. This enables a new approach to urban planning by allowing computationally generated forms to be visualised in GIS software. These tools produce iterative, smarter urban solutions, which can be shared on a wider platform. This paper introduces and details Humpback's creation, evaluates the tool, as well as its application to Mapbox, a GIS platform and its potential for Urban Pinboard, a web-based GIS platform.



Humpback translates computational forms to GeoJSON script © Madeleine Johanson & Nazmul Khan

This paper was first published in: The Proceedings of the 3rd Annual International Conference on Urban Planning and Property Development (UPPD 2017)

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Optimising Image Classification: Implementation of Convolutional Neural Network Algorithms to Distinguish Between Plans and Sections within the AEC Industry

Jennifer Mei Yee Ng,
Nariddh Khean,
David Madden,
Alessandra Fabbri,
Nicole Gardner,
M. Hank Haeusler and
Yannis Zavoleas

Keywords.
Convolutional Neural Network; Artificial Intelligence; Machine Learning; Classification; Filing architectural drawings.

Industry Partner.
ARUP Sydney

Modern communication between built environment professionals are governed by the effective exchange of digital models, blueprints and technical drawings. However, the increasing quantity of such digital files, in conjunction with inconsistent filing systems, increases the potential for human-error upon their look-up and retrieval. Further, current methods are manual, thus slow and resource intensive. Evidently, the architectural, engineering and construction (AEC) industry lacks an automated classification system capable of systematically identifying and categorising different drawings. To intercede, we aim to investigate artificially intelligent solutions capable of automatically identifying and retrieving a wide set of AEC files from a company's resource library. We present a convolutional neural network (CNN) model capable of processing large sets of technical drawings - such as sections, plans and elevations - and recognise their individual patterns and features, ultimately minimising laboriousness.

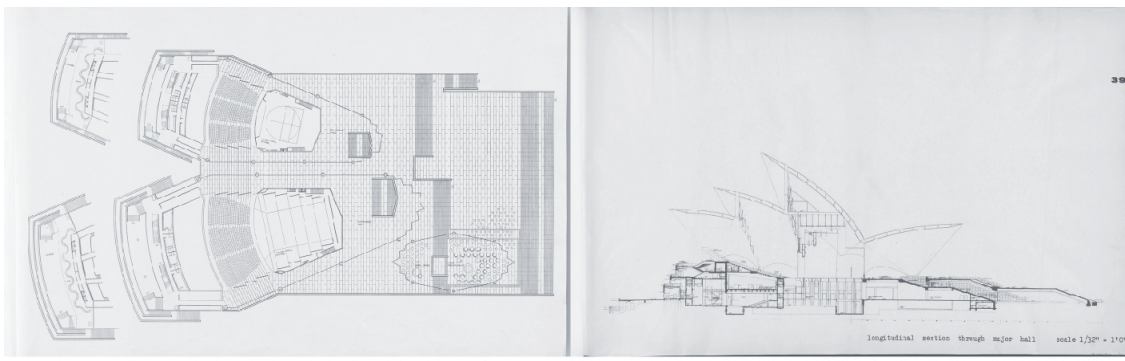

Image: "First_Floor_Plan_(Sydney_Opera_House)_(5373..." Prediction: **Plan drawing with 99.72% confidence**

Image: "12708_00041.jpg" Prediction: **Section drawing with 100.00% confidence**

Sydney Opera House drawing predictions. Credit: Jennifer Mei Yee Ng

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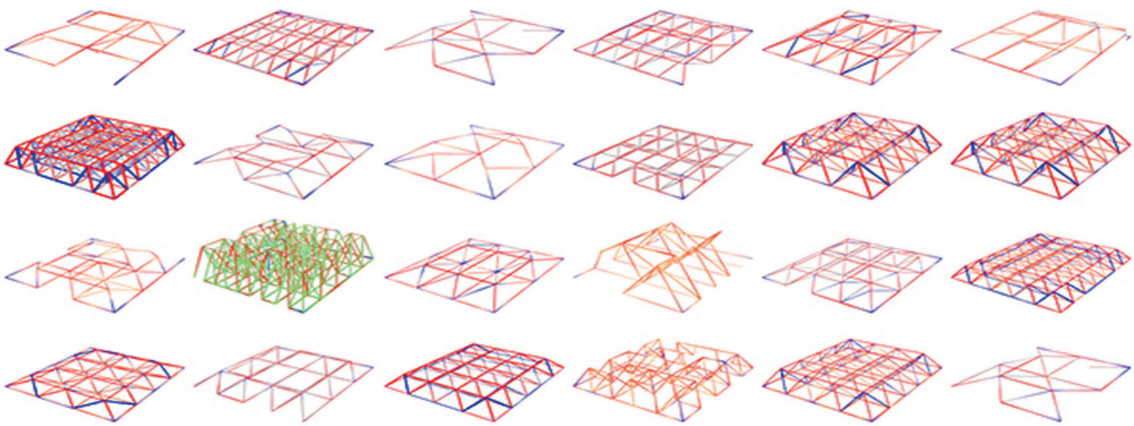
Building Intelligence through Generative Design: Structural Analysis and Optimisation Informed by Material Performance

Ryan Johan,
Michael Chernyavsky,
Alessandra Fabbri,
Nicole Gardner,
M. Hank Haeusler and
Yannis Zavoleas

Keywords.
Intelligent Systems; Generative Design; Material Properties; Structural Analysis; Evolutionary Algorithms

Industry Partner.
Aurecon Sydney

Generative design (GD) is the process of defining high-level goals and constraints and then using computation to automatically explore a range of solutions that meet the desired requirements. Generative processes are intelligent ways to fast-track early design stages. The outcomes are analyzed simultaneously to inform decisions for architects and engineers. Whilst material properties have been defined as a driving agent within generative systems to calculate structure, material performance or structural capacity are not linked with early decision-making. In response, this paper sets a constrained approach upon traditional and non-traditional materials to validate the feasibility of structures. A GD tool is developed within Grasshopper using C-sharp, Karamaba3D, Galapagos and various engineering formulas. The result is a script, which prioritizes the structural qualities of material as a driving factor within generative systems and facilitates communication across different expertise.



Various optimisation results for planar space truss systems © Ryan Johan

This paper was first published in: M. Haeusler, M. A. Schnabel, T. Fukuda (eds.), Intelligent & Informed Proceedings of the 24th CAADRIA Conference - Volume 2, Victoria University of Wellington, Wellington, New Zealand, 15-18 April 2019, pp. 371-380

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Developing a Workflow for Daylight Simulation

Alexander Lee,
Suleiman Alhadidi and
M. Hank Haeusler

Keywords.
Data-driven design; computation environmental design; daylight simulation; Green Star.

Industry Partner.
HASSELL Sydney

Daylight simulations are occasionally used as active tools in regards to local governing regulations, which are necessary for providing documentation. Simulation tools have been avoided in the past due to their barriers. Daylight simulation tools are used within documentation design stages as 'passive tools', however they do not have a direct impact on the architecture design decisions, as passive tools are used by engineers usually to derive material and glass specifications. Recent developments within an online community have provided designers with access to daylight simulation tools within a design platform accessible data can be modified and represented with local governing codes to provide designers with relevant information. The paper aimed to develop an active daylight simulation tool within a design platform. Data is filtered with the Green Star benchmarks to export visual information as well as a voxel matrix instead of 2D luminance maps. This paper outlines a workflow of the simulation tool used to evaluate daylight performance of a selected building as a case study in real time. The paper also details potential problems and justified suggestions derived from the analysis for the building to reach the requirements within the Green Star Multi Unit Residential.

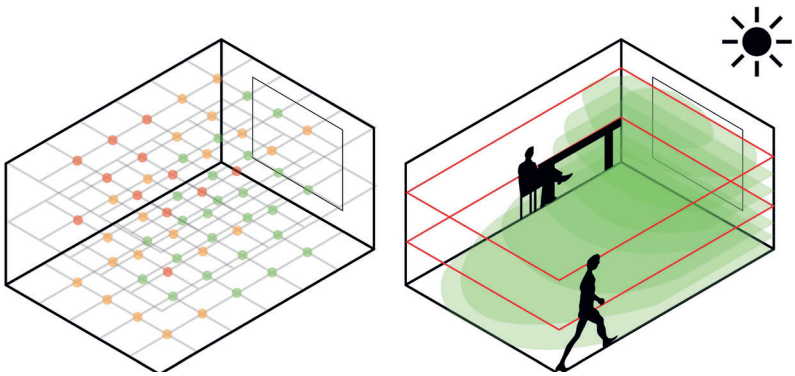

Figure 1. Concept diagrams of 3D daylight simulations. (1) Voxel based simulation, grid representation (2) Mesh representation of lux value contour lines. © Alexander Lee

This paper was first published in: Living Systems and Micro-Utopias: Towards Continuous Designing, Proceedings of the 21st International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2016)/Melbourne 30 March–2 April 2016, pp. 363-372

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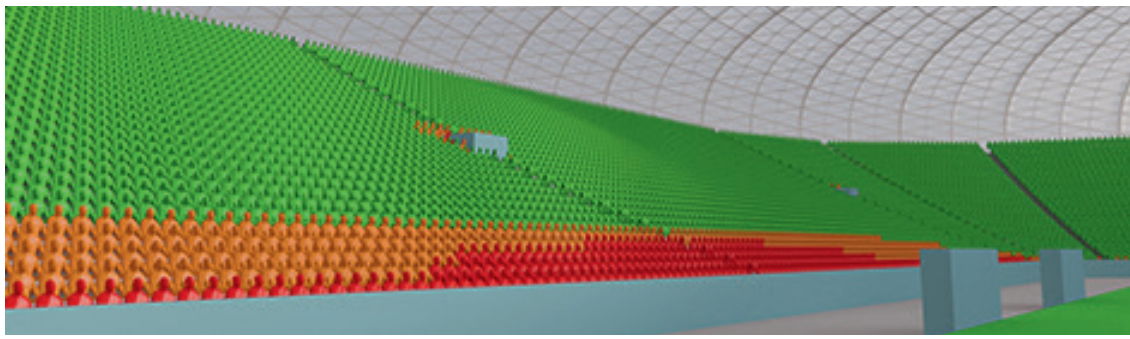
Optimisation for Sport Stadium Designs: Advantages for Shifting from Macro Level to Micro Level viewing Optimisation in Stadium Design

Daniel Joseph,
Alan Kim,
Andrew Butler and
M. Hank Haeusler

Keywords.
Stadium design; Design optimisation; Design analysis; Customised software develoment; Grasshopper scripting.

Industry Partner.
COX Architecture Sydney

Applying computational optimisation tools for sport stadium designs has become common practice. However, optimizations often occur only on a macro level (analysing stadium as a whole) and not on a micro level (a view from each seat). Consequently, items on a micro level with design details like guardrails can be overlooked, leading to financial losses for operators. Hence, the research argues that every seat is encouraged to have a clear field of view to avoid financial complications. In order to address this problem the research team developed and evaluated a script that allowed importing an existing design into Rhino. Firstly, the script evaluates the view of each seat via a colour coded response system. Secondly, the designer can select the respective seat, and view the sightline from the occupant's sightline to various spots on the field to analyse where the obstruction is occurring. This 'binocular view' enables the designer to evaluate blind spots from each seat prior to project completion. As the script allows the designer to automate the micro level analysis, the research arguably provides a significant improvement for stadium design by comparing the time used for a design optimisation in a conventional method with the automated one.



Stadium layout with colour coded optimisation for viewing © Daniel Joseph

This paper was first published in: Emerging Experience in Past, Present and Future of Digital Architecture, Proceedings of the 20th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA 2015)/ Daegu 20-22 May 2015, pp. 573-582.

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Computational design is a post-disciplinary pursuit that operates at the intersection of science, engineering, architecture, and design.

What new strategies, tools, methods, and workflows for conceptualising, generating and producing the built environment do and can computational designers use?

Do new opportunities to enhance design agency and realise more sustainable and resilient built environment design outcomes exist when thinking through technology?

How can the architecture, engineering and construction (AEC) industry overcome technical, economic, social, cultural, and regulatory barriers to implement new systems and processes?

Computational Design: From Promise to Practice argues that to realise the full potential of computational design necessitates an approach that brings theory and research inquiry into closer dialogue with the realities and conditions of the design, delivery, and production of the built and urban environment as well as its lived-experiences.

This book documents an action-research approach that underpins the Computational Design Education and Research program at the University of New South Wales, Australia and that simultaneously combines theory and practice, researchers and industry practioners, and action and reflection. The innovative range of theoretical positions and projects presented here demonstrate how a synergistic approach to transforming real-world industry challenges into academic research inquiries and learning opportunities can in-turn positively transform the AEC industry and 21st century cities.

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