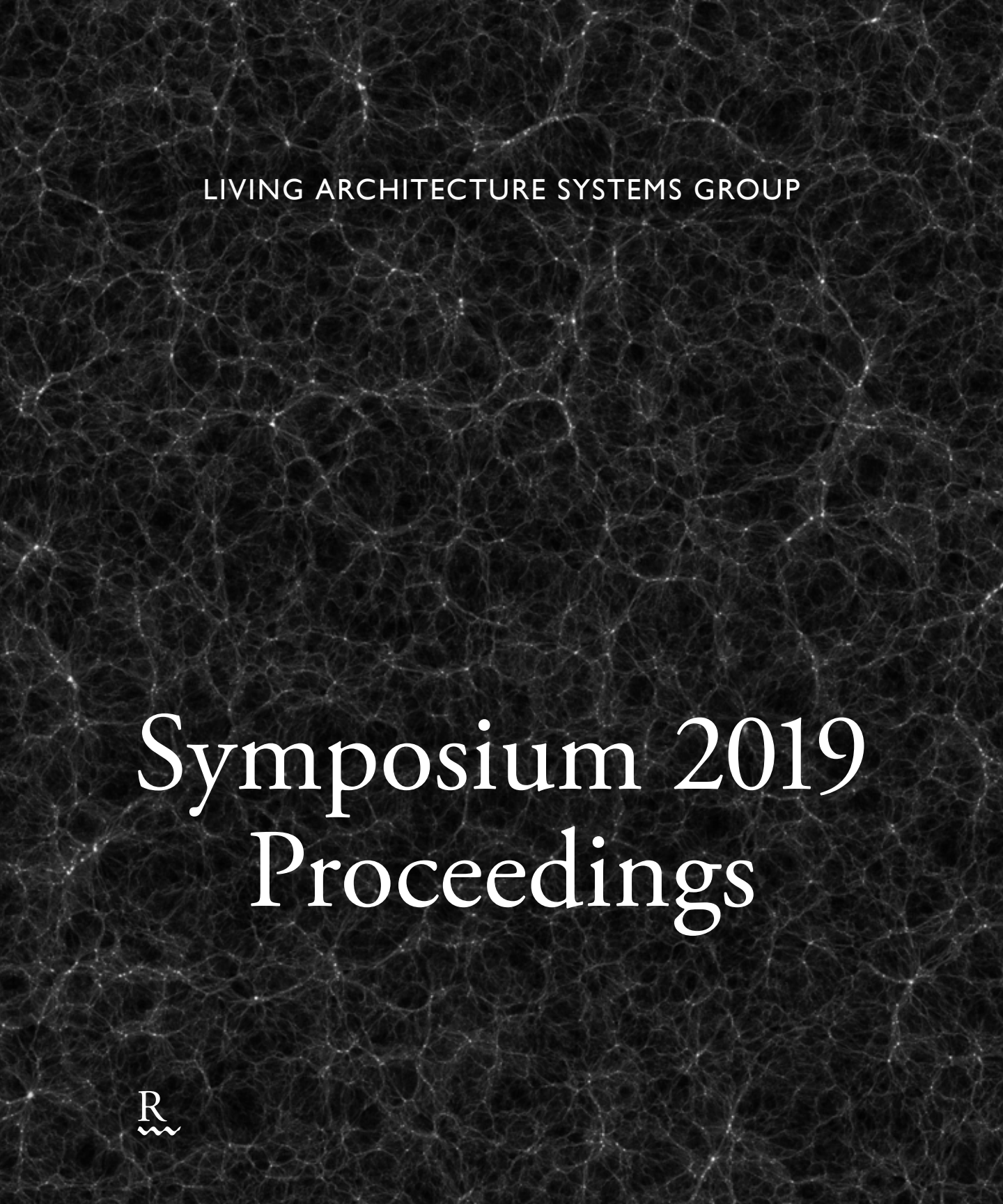
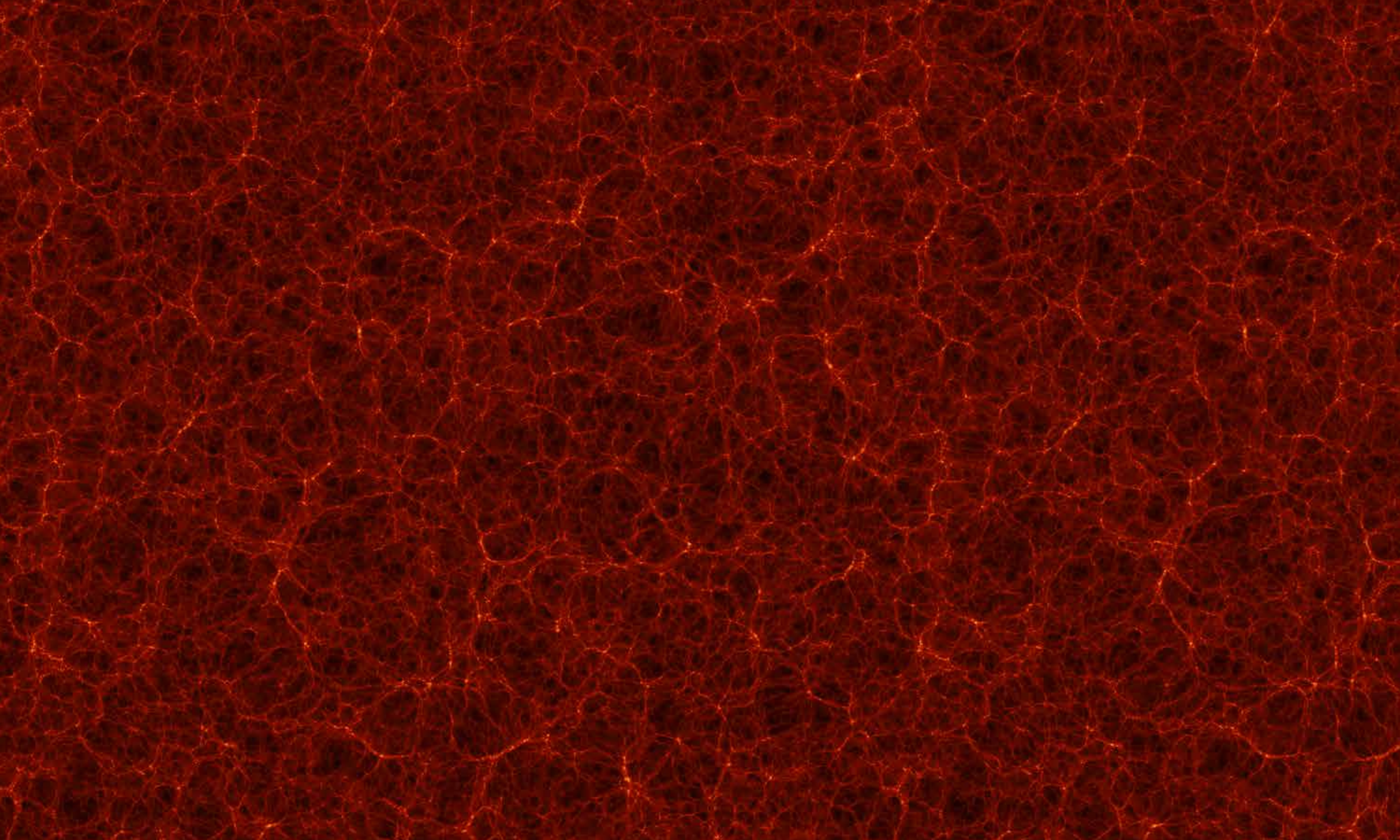

LIVING ARCHITECTURE SYSTEMS GROUP
Symposium 2019
Proceedings



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Cover: Modification of a high resolution slice of the sholeMpc box of Bolshoi. Made by Stefan Gottlober (AIP) with IDL. Last accessed February 12, 2019 at http://hipacc.ucsc.edu/Bolshoi/. The Bolshoi simulation is the most accurate cosmological simulation of the large-scale structure of the universe yet made ("boshoi" is the Russian word for "great" or "grand"). The filamentary cellular structures evident within the Bolshoi simulation bear a striking resemblance to the organization that can be seen throughout natural living forms. The Principal Investigators of the Bolshoi project are Anatoly Klypin and Joel Primack.

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LIVING ARCHITECTURE SYSTEMS GROUP

Symposium 2019 Proceedings

March 1–3, 2019 Toronto, Canada

in association with University of Waterloo and Ontario College of Art and Design University

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Introduction

The Living Architecture Systems Group (LASG) celebrates the halfway mark of its multi-year SSHRC Partnership Grant with the LASG Symposium 2019. Forty-four papers and twenty poster presentations from three continents, workshops, an exhibition and multiple studio prototypes are gathered here, reflecting the increasing depth of the group. Seven broad themes of research and creation have emerged:

Open Boundaries and Expanded Dimensions explores the scales of new adaptive and responsive architecture, from intimate personal spaces to regional infrastructures.

Subtle Phenomena and Expanded Perception explores dimensions at the edges of human perception. These move from primary, existential qualities of light and dark through interwoven social realms. Immersive sonic environments and precise measurements using innovative sensors of physiology are included.

Making Vibrant Matter reflects the unparalleled new abilities of designers to precisely address material performance. Striking qualities are being achieved by applying the principles of biological structures to architectural components. Innovative design methods are included that combine meticulous control of computationally derived geometry with deeply involved material craft.

In *Hybrid Nature*, extraordinary efflorescence of hybrid architectural constructions can be found crossing traditional boundaries between nature, technology and urban realms. New mutual relationships that couple human, animal and mineral realms are invoked.

Synthetic Cognition includes innovative interactive machine learning within large distributed systems involving multiple viewers and occupants. Specialized software applications support distributed mesh-based multi-sensory expression. Stage and dance performance-based interactive works couple actors and audience members with immersive environments.

Kinetic Architecture documents evolving research in dynamic, adaptive construction and mechanisms that transform the fabric of architecture. Integrated robotic construction systems offer efficiency and versatile expressive manipulations of form. Elastic and resilient mechanisms manifest transformed kinetic qualities that approach empathetic, emotional gesture.

Past and Future Living Architecture present new reflections that place the work of the LASG within traditions including historic conceptions of Organicism, 20th century participatory art and open systems, and radiant geometries related to Aquarian Age conceptions.

Eminent interaction theorist and designer Paul Pangaro, Professor of the Practice in the Human-Computer Interaction Institute at Carnegie Mellon University delivers a keynote address on interaction design including iconic works by Gordon Pask. A second keynote focusing on next-generation visualizations of complex data is offered by Katy Börner, Distinguished Professor of Engineering & Information Science at Indiana University.

The Amsterdam 4DSOUND collective demonstrates an immersive sound, light and motion environment, accompanied by multiple prototypes in progress. Toolbox Dialogue Initiative from Michigan State University offers a workshop addressing definitions of responsive and living architecture, exploring working methods and motivations through a series of co-creation exercises. Carole Collet of Central St. Martins UAL leads a workshop focusing on theoretical positioning and research sources for the rapidly-emerging field related to this topic. The exhibition and accompanying publication Resurgence of Organicism, curated and edited by Sarah Bonnemaison, explores principles of Organicism in architectural theory and design, past and contemporary.

Every study within this gathering is interdisciplinary. Meticulous new precisions are emerging, offering highly developed technical craft and nuanced aesthetic language. The sheer diversity of these studies suggest that the topic of Living Architecture is volatile, testing the limits of classical definitions and design paradigms.

Can architecture be defined as living? The research and creative explorations offered here suggest that paradigms previously reserved for natural life are now directly relevant to architecture. The gathering invites perception of a continuous spectrum from mineral to organic to sentient forms within the built environment. We seem to be at early stages of fundamental transformations, creating mutual relationships at intersections of nature and technology.

Philip Beesley

Philip Beesley (Canadian, 1956) is a multidisciplinary artist and architect. Beesley's research is widely cited for its pioneering contributions to the rapidly emerging field of responsive interactive architecture. He directs Living Architecture Systems Group (LASG), an international consortium of researchers, creators and industry partners. LASG explores questions such as whether architecture can integrate living functions and future buildings could think and care. LASG's immersive installations integrate expertise in architecture, environmental design, visual art, digital media, engineering, machine learning, cognitive psychology, synthetic biology and knowledge integration. Collaborations with LASG artists, scientists and engineers has led to a diverse array of projects, from haute couture collections to complex electronic systems that can sense, react and learn.

Beesley is a professor at the School of Architecture at the University of Waterloo and Professor of Digital Design and Architecture & Urbanism at the European Graduate School. He represented Canada at the 2010 Venice Biennale of Architecture. He has authored and edited numerous books and proceedings, and has been featured in Canadian and international media, including Vogue, WIRED, Artificial Life (MIT), LEONARDO, CBC, and a series of TED talks.

Image LASG research outline diagram showing twenty-year progression towards fully interconnected environments

Keynotes

Keynote

Less Interference/More Dance

Paul Pangaro
Carnegie Mellon University, Pittsburgh, USA

Gordon Pask designed his "Colloquy of Mobiles" for the groundbreaking 1968 exhibition *Cybernetic Serendipity*, where Colloquy was by far the most ambitious, outlandish and revolutionary work. Life-sized mobiles interacted with each other and with the audience through light and sound, "conversing" in multi-layer engagements. Seeming to have fallen from outer space, Colloquy brings continuity between Pask's interactive machines of the 1950s and his rigorous cybernetic theory of conversations of the 1970s. He was always asking, What is conversation? And how can novelty in conversation lead to new experiences and novel concepts?

While fabricating a full-scale replica of Colloquy at the College for Creative Studies, we imagined how astonishing it must have been in 1968. Yet we were unprepared for its impact in 2018: audiences of interaction designers, media artists, students, scholars and the general public all found Colloquy's organic, analog presence to be utterly seductive. What were Pask's questions fifty years ago such that he could create Colloquy then? What would he be saying to us today?

He would certainly scoff at the digital computers in our pockets that interrupt us incessantly, without offering much by way of his notion of "novelty." For Pask, as in his Colloquy, conversation is a dance of serendipity and synchronization, surprise or disengagement, in a quest for what is new. Today's tech takes our attention for its purposes, while we spend almost none of our on-screen time in conversation. We mistake interference for interaction and are distracted from being ourselves. Without the social exercise of human-to-human engagement, our brains atrophy. We are left with "obesity of the brain." The results are inanities and even broad cultural change as when, for example, social media brings a contagion of "fake news" and thence a decline of democracy.

Pask's machines fore-fronted novelty in order to foster interaction. Today we can imagine that Pask would replace the Turing Test, where a human will judge whether a programmed machine is "intelligent," with a Conversation Test, where a program would judge whether a conversation might be "generative," that is, fruitful and energetic, self-driving because it stimulates our human curiosity for "the new." Instead of "better" movies to watch, such a program in our pocket could guide us to better interactions. Perhaps a new era of human-computer interaction?

About those "recommendation engines" and "search engines" — can't we see that they use our past to paint us a future more in their interest than in ours? They want to "monetize" us based on who we've already been. We mindlessly adopt AI technology that decides what we were, rather than offering up what we could be. But as conscious creatures we "live in the now" — wouldn't we rather define our own future, our own becoming? We should be open to suggestions, sure — but these should be in the form of questions, not answers. Answers are dead (though admittedly some are useful). Questions are alive! Where is the Paskian novelty we need to keep up our energy and curiosity? Make me alive: make me a Question Engine to rev up our conversations.

Perhaps the strongest provocation from Pask via Colloquy is this: we are biology. We are analog creatures that crave flow and engagement, coherence and delight. Just as Colloquy's mobiles have bodies and behaviors, our bodies and behaviors are comprised of overlapping, simultaneous senses and feelings and actions, all ongoing. Our organic logic is analog, we process in real-time, "in the now." These damn digital devices, these pixelized,

splintering, flattening, trivializing interfaces are in our way. As human beings we want what we want even if we don't yet know what that is. We want to become and want to flow into whatever that means. We want to make our own meaning, together.

Pask is asking, can we embrace our biology and "design for analog"? Colloquy's proposal from fifty years ago is still astonishing, asking us, what might we make together today? Let us begin:
less interference, more dance

Paul Pangaro has been designing conversational interfaces for forty years, though not the ones of today, such as Alexa and Siri. At MIT he received a B.S. degree in Humanities/Computer Science and then was hired by Nicholas Negroponte onto the research staff of the MIT Architecture Machine Group, predecessor of the MIT Media Lab. There Pangaro met Gordon Pask with whom he earned a Ph.D. in Cybernetics at Brunel University (UK). He then pursued a career as entrepreneur, teacher, researcher and consultant. He has worked with and within software startups in New York, Boston and the Silicon Valley in product and technology roles. As a consultant, Pangaro has been engaged by Du Pont, Nokia, Samsung, Instituto Itaú Cultural (São Paulo), Ogilvy & Mather, Eight Inc and PoetryFoundation.org. His published papers explicate "designing for conversation" from his research and his implementations of software products and organizational processes. His most recent project is the full-scale replication of Pask's Colloquy of Mobiles at the College for Creative Studies in Detroit, while he was Chair of the MFA Interaction Design program. In January 2019 Pangaro became Professor of the Practice in the Human-Computer Interaction Institute at Carnegie Mellon University.

Image Less Interference/More Dance

In the year of its 50th anniversary, Gordon Pask's Colloquy of Mobiles was replicated by the MFA Interaction Design Department, College for Creative Studies, Detroit, Michigan, USA. A visually and behaviourally faithful reproduction of the original installation at the ICA in London in 1968, Colloquy's striking presentation of analog, organic, immersive and asynchronous conversations, both machine-to-machine and machine-to-human, challenges many of our 21st-century assumptions about technology and interactivity. The project was made possible by the generous support of its advisory board, private donors, Design Core Detroit, the Living Architecture Systems Group (through a SSHRC grant), and the college's provost, Bill Shields. The full-scale replica was designed and constructed by TJ McLeish, master fabricator of the project; Paul Pangaro was project lead.

Keynote

Envisioning the Internet of Things

Katy Börner with Andreas Bueckle
ISE and ILS, School of Informatics, Computing, and Engineering
Indiana University, Bloomington, USA

In this talk, we present two streams of extended collaboration between the Living Architecture Systems Group (LASG) and the Cyberinfrastructure for Network Science Center (CNS) at Indiana University (IU). Both collaborations revolve around the *Amatria* sentient sculpture on display at Luddy Hall, IU Bloomington, USA since Spring 2018 (https://cns.iu.edu/amatria.html).

First, we will introduce our joint work on Dendrite and Moth kits that resemble *Amatria* and are meant to introduce Internet of Things (IoT) setups to general audiences. So far, seventy "children of *Amatria*" have been built, discussed, interconnected, taken home and brought back to *Amatria* for events.

Second, we will present Tavola, an app visualizing the location of sensors and actuators in *Amatria* as well as the value of one infrared (IR) sensor. Tavola enables deeper exploration of the Amatria setup and aims to add another dimension to the visitor experience. We will discuss the research and development process of Tavola that uses the data visualization literacy framework (DVL-FW) to design insightful visualizations together with challenges and future developments.

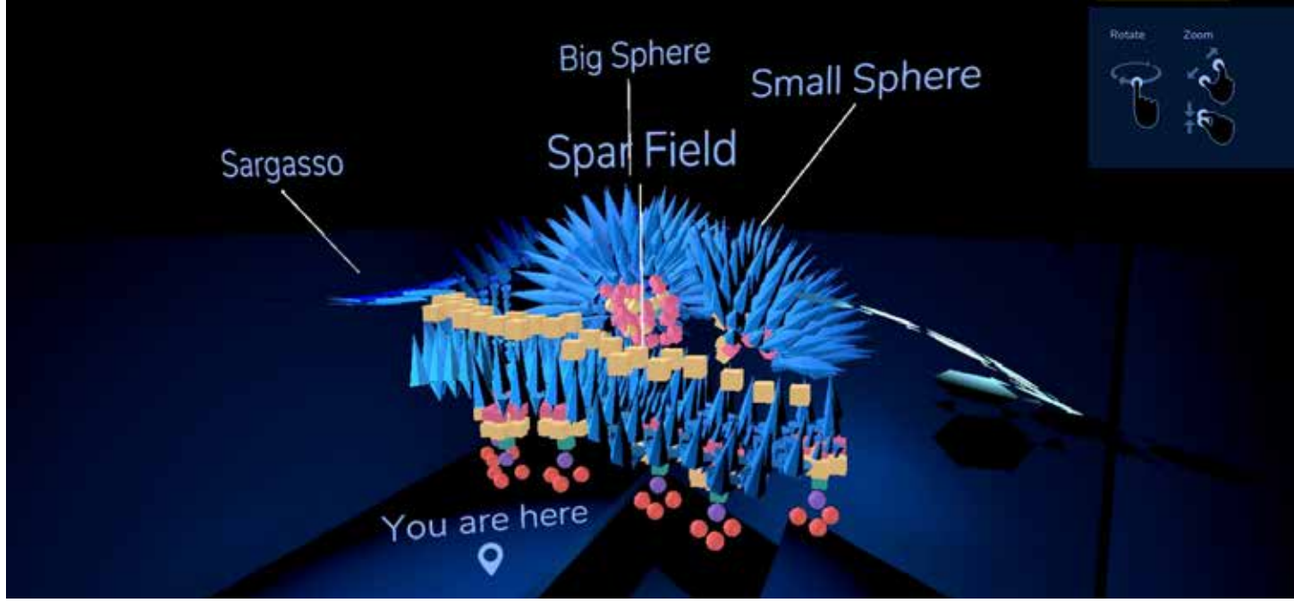

Image Tavola, a 3D interactive visualization of Amatria

Katy Börner is the Victor H. Yngve Distinguished Professor of Engineering and Information Science in the School of Informatics, Computing, and Engineering, an Adjunct Professor at the Department of Statistics in the College of Arts and Sciences, a Core Faculty of Cognitive Science, and the Founding Director of the Cyberinfrastructure for Network Science Center at Indiana University, Bloomington, IN. She is a curator of the international Places & Spaces: Mapping Science exhibit that features large-format maps and interactive data visualizations. Börner holds a M.S. in Electrical Engineering from the University of Technology in Leipzig, 1991 and a Ph.D. in Computer Science from the University of Kaiserslautern, 1997. She is a member of ACM and IEEE and is an American Association for the Advancement of Science (AAAS) Fellow and a Humboldt Research Fellow.

Andreas Bueckle is a Ph.D. candidate in Information Science in the School of Informatics, Computing, and Engineering at Indiana University. Coming from a background in video journalism and media, Andreas performs research and development of data visualizations in augmented and virtual reality, exploring the possibilities to visualize and allow for immersive interactions with data in 3D worlds. He holds a B.A. in Media Studies from Eberhard Karls University in Tüebingen and an M.A. in Communications in Economic and Social Contexts from Berlin University of the Arts (Germany).

Open Boundaries and Expanded Dimensions

Metabolic Design
Towards Radical Co-authorships

Simone Ferracina
The University of Edinburgh, Scotland

The application of living technologies to buildings and cities promises to catalyse a shift from fossil fuels to the wet and soft burning of metabolisms, inviting buildings to become responsive, ecologically active and productive. This broadening of architecture's scope demands new rules, methods and priorities, challenging the inertia of buildings, the primacy of human experience and the traditional role of the architect. Yet, perhaps more importantly, it prompts a rethinking of design practice as defined by protocols of human control and authorship. The talk introduces a metabolic understanding of architectural objects and materials; one that seeks adaptability both in the ability of outputs to undergo future changes and in the capacity of pre-existing substrates to inform and steer designs. Here, objects exist within a deep continuum that necessarily exceeds generations and intentions, and values are attributed both from within and without the architectural project and its scripts—challenging authorial purity and promoting fluid definitions, affordances and ecologies of use.

Image Simone Ferracina. The Memory of Parts. Carliol House as a living and monstrous archive.

Simone Ferracina is a Lecturer in Architectural Design/Detail at the Edinburgh School of Architecture and Landscape Architecture (ESALA), where his research and teaching investigate radical modes of co-authorship, the reactivation of wastes and metabolic design. He is a member, with Rachel Armstrong and Rolf Hughes, of the Experimental Architecture Group (EAG), a collective whose work has been exhibited and performed internationally. Simone is the Founder and Editor of the online journal Organs Everywhere (OE), and the Director of the OE Case Files imprint in collaboration with Punctum Books— a platform for questioning architecture's boundaries, technologies, methods and evaluation systems. Prior to joining the University of Edinburgh, Simone was a research assistant (EU H2020 Living Architecture) at Newcastle University and, for over a decade, an associate and project manager/architect at Richard Meier & Partners Architects in New York City, with award-winning projects in Italy, Czech Republic and Taiwan.

Would You Like to Wake Up from this Dream? Yes, I'm Terrified
An Argument for a Machinic REM

Alexander Webb
University of New Mexico, Albuquerque, USA

If the trauma of the post-anthropocentric successfully reframes our relationship to artificial intelligence, then we are charged to question the underlying assumptions of neural networks and deep learning. Do the hierarchies that are entrenched in the creation of Artificial Intelligence (AI), the mechanisms that position us as controlling providers of learning fodder, liberate AI or only continue to restrain it under the guise of equity? Could alternative models be of use, ones that allow AI to learn on its own terms?

This presentation suggests that a biomimesis of the mammalian phenomenon of dreaming could produce a more robust learning algorithm, while responding to the call of the post-anthropocentric. Using Matthew Lai's chess program Giraffe, Hod Lipson's Starfish, and After Input's Odd City as examples, this presentation will suggest that a greater agency for machinic intelligence has radically productive results, and will argue to increase that agency even further.

Image Bina 48 by Hanson Robotics Limited

Alexander Webb is the Associate Professor of Emergent Technology at the School of Architecture and Planning at the University of New Mexico, and a Ph.D. candidate at the European Graduate School for Digital Design. Alex is the Committee Chair of the Computational Ecologies track for the Masters of Science Degree at the University of New Mexico, and has collaborated with and worked for firms such as Marmol + Radziner, Patterns, Coop Himmelb(l)au, Xefirotarch, Jones Partners Architects, and Gensler. Alex holds a Master of Architecture from the Southern California Institute of Architecture, a Bachelor of Arts from Colorado College, and has also studied architecture and design at the Berlage Institute and Columbia University.

Space Architecture

Barbara Imhof

LIQUIFER Systems Group GmbH, Vienna, Austria

The talk will explore the implications of space as an environment for future habitation both materially and conceptually. Research and development projects of LIQUIFER - implemented as part of the European space exploration programme - highlight topics of living with limited resources in limited spaces and living self-sufficiently. Concept studies for lunar and Martian bases as well as building prototypes set within future scenarios for living on earth and in space form the basis of LIQUIFER's work. Arts-based and basic research in the fields of biomimetics and integrating biological systems into architecture add to the circular systems perspective of future narratives for our extended world.

Barbara Imhof is a space architect, researcher and educator. She is also the co-founder and co-manager of LIQUIFER Systems Group that comprises experts from the fields of architecture, design, human factors, systems engineering and science. Their space-related projects focus on feasibility and scenario studies as well as designing and building mockups and prototypes. LIQUIFER partners with renowned research institutions and well-known enterprises to conduct research and develop technology under contracts from the European Space Agency and the EU-Framework Programmes.

As project lead Imhof currently works on the Gateway project, designing the habitat module for the next International Space Station in a lunar orbit. She has also led projects such as SHEE, the first built European simulation habitat and project MOONWALK, developed to test human-robot collaborations for space exploration. Further, Barbara pursues projects in the field of biomimetics and closed-loop systems such as Living Architecture and GrAB–Growing As Building.

Image Self-deployable Habitat for Extreme Environments SHEE as part of project MOONWALK Mars simulations in Rio Tinto, Spain. Photo credit: Bruno Stubenrauch, 2016

Living Infrastructure

Douglas MacLeod
RAIC Centre for Architecture at Athabasca University, Canada

The RAIC Centre for Architecture continues to explore both virtual design and regenerative design. Based on Odile Decq's idea of architectural thinking, the Centre is deploying a transdisciplinary approach to the built environment. In particular, through its membership in groups such as the Smart, Sustainable and Resilient Infrastructure Association it is using these research themes to develop ideas for new forms of infrastructure.

Key projects in these endeavours include:

- The development of an inter-institutional and interdisciplinary AR/VR network
- The creation of a Green Building Testbed Network which will include a future skills network and a virtual incubator for new products and services
- The prototyping of a music instrument interface to virtual reality
- The staging of the second Sustainable Building Science Workshop and Festival
- The creation of a science fiction prototyping approach to the impact of AI on learning
- The opening of a repository of Open Educational Resources related to architecture
- The hosting of Virtual Roundtables on Diversity in the AEC Industry and Zero Carbon Buildings
- The delivery of a Dual Credit Design Boot Camp with Edmonton Public School Board
- The publication of an online Regenerative Design Matrix to help design buildings that are more than sustainable

Much of this work is focused on how we use integrate technologies and methods such as project-based learning, OER's, Blockchain, BIM and the Internet of Things to create different approaches to the design and construction of the built environment. For example, the Green Building Testbed Network, referenced above, will model, meter, secure and analyse the data produced by green buildings using an integrated suite of tools ranging from MatchBox Energy software (for modeling) to wireless sensors (for measuring) to blockchain for data security. As this diagram shows, however, the real opportunities enabled by these technologies is the synergies that result when they are combined together.

The intent is to use these new opportunities to explore pressing problems from different perspectives. As noted, critical issues such as diversity have been examined with virtual roundtables; sustainable building science is being addressed with Global Classrooms (developed by our partner at Tech Monterrey) and interactive Regenerative Matrices; and we hope to continue to use science fiction prototyping on an ongoing basis to spur imaginative new scenarios for the future.

This approach is very much aligned with the LASG efforts to create environments which are alive and empathetic. In effect, we have the potential to re-imagine the built environment as a platform of of inter-operable, inter-connected, modular approaches, products and services that help not one project but all of them.

Dr. Douglas MacLeod is the Chair of the RAIC Centre for Architecture at Athabasca University – Canada's first online architecture program. The Centre currently serves over 600 students in 16 countries and continues to enhance the quality of architectural education in Canada. MacLeod is a registered architect, a contributing editor to Canadian Architect Magazine and the former Executive Director of the Canadian Design Research Network. He is also a former Associate with Barton Myers Associates, Los Angeles. He led pioneering work in virtual reality at the Banff Centre and is recognized as an expert in e-learning, sustainable design and virtual design. He has degrees in Architecture, Computer Science and Environmental Design and has taught at universities and colleges throughout North America.

Bioregional Innovation Lab

A Brief Sketch of the Coming Restoration Economy

J. Eric Mathis
Institute for Regenerative Design and Innovation, Winston Salem, USA

How can understanding the Living Architectures of the cosmic web, brain neurons, mycelial networks and regional innovation clusters help us address some of today's most pressing concerns such as climate change, soil depletion, racial inequality, poverty and general health disparities? Building from over fifteen years of experience as a practitioner of sustainability, J. Eric Mathis will share a brief history of how he (along with many others) has identified numerous solutions to today's most perplexing problems, with a specific focus on the importance of coupling Curriculum Design and Health Innovation within the emerging field of Regenerative Entrepreneurship. The accumulated solutions he and others have identified are now being assembled into a rich and deeply complex Living-Lab Platform in his home city of Winston Salem, NC, which will serve a regional hub for the Great Appalachian Valley. Utilizing Keller Easterling's extremely fruitful architectural concepts of "multipliers" and "switches" for assembling the platform's design protocols, the emerging Bioregional Innovation Lab (or iLab) is poised to become a national model and is intentionally designed to accelerate the United States' transition from an economy of scarcity to one of abundance. This presentation will provide a brief sketch of the coming Restoration Economy. For a primer please watch 2016 TEDxAsheville: "Exploring the Potential Worlds of Living Architecture."

Image Mycelial networks.

J. Eric Mathis has been at the forefront of Regional & Urban Design strategies throughout the Southeast United States with a specific focus on regenerative design and innovation. Serving as the co-Director of the Institute for Regenerative Design & Innovation and building from his experience in both regional & urban planning in central Appalachia, Mathis is presently co-designing a regionally focused design-protocol referred to as a Living-Lab Platform. These platforms are engineered to breed both local and regional "circular-assets" within the energy and agriculture sectors – collectively forming a comprehensive Bio-Regional Development model rooted in an ag/energy nexus strategy.

Mathis is a Green for All Fellow, a 2010 recipient of Interstate Renewable Energy Council's Innovation Award for community renewables and a 2012 White House Champion of Change for Greening our Cities and Towns. Mathis lectured at MIT as part of the 2013-2014 Sloan Sustainability Speaker Series, and has been both a speaker and a moderator of panels at many economic/sustainability conferences. His collaborative work has been covered by or featured in Biodiesel Magazine, BBC World News, Eye Opener TV, Bloomberg, Photon Magazine, Daily Yonder, West Virginia Executive Magazine, Fast Company, Home Power Magazine, PBS News Hour and Fortune Magazine.

Applying 3D Scanning and 360° Technologies to Complex Physical Environments

Codrin Talaba
Independent Design Researcher, Toronto, Canada

This talk will discuss how 3D scanning and 360° media are different from conventional 2D methods to document complex physical environments and their interactions with occupants. By removing the frame and expanding the field of view, these technologies provide a new way of seeing and capturing the world - through the sensors of machines. This gives new agency to end-users to alternate between vantage points, scales and layers of data to virtually experience a location in ways that are not possible physically.

Two proof-of-concept prototypes will be introduced that apply these tools to art installations by the Living Architecture Systems Group. This will be divided into four parts:

- Learning to Switch Perspectives discusses how the capture of 3D or 360° content can be improved by shifting between a human point of view and the way machines capture data.
- Seeing from the Machine's Perspective takes the reader on a visual journey through the eyes of the machine to help bridge the different ways of seeing and collaborate better.
- Sense Making Through Sensors and Lenses describes how 3D and 360° data can be visualized and utilized to enable better human understanding of complex environments.

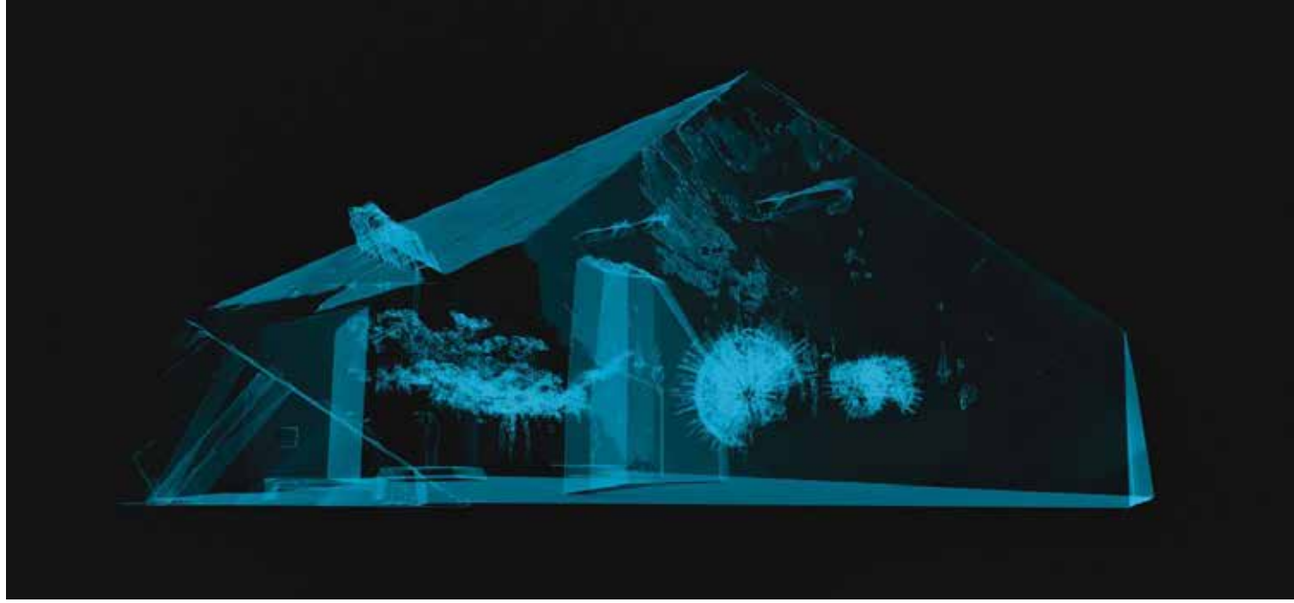

Image 3D scan of as-built conditions of the Royal Ontario Museum during LASG's Aegis and Noooshpere exhibition reveals hidden dimensions

- Digitize / Replay / Iterate introduces the potential of using 360° video to capture more dynamic records of the interactions with building occupants – for archiving and analysis.

Learning how to intentionally switch between these physical and virtual dimensions can shift the ways humans perceive, analyze, document and understand complex physical environments. The multiple perspectives gained from 3D scanned models and 360° footage can be used as collaborative and iterative design research tools towards a learning, living architecture.

Codrin Talaba is a design researcher who explores the use of immersive technologies to enable better design planning, collaboration and storytelling. With a background in architecture, engineering and visual arts, he brings a multi-disciplinary approach (and curiosity) that seeks to introduce new perspectives to every project.

Talaba is the media and content specialist on UHN OpenLab's Prescribing VR initiative to introduce virtual reality in healthcare studies and settings. He also develops novel uses of 3D scanning and virtual reality for art, architecture and enterprise applications. He has worked on research and design projects as diverse as the Aga Khan Museum, Sinai Health Systems, Bank of America, Acconci Studio, Edelkoort Inc., Land Rover and the United Nations. Talaba is one of the newest collaborators of the Living Architecture Systems Group.

Subtle Phenomena and Expanded Perception

Darkness by Day

Catie Newell
University of Michigan, Detroit, USA

Our trust in light does not gives us grounds to understand darkness. It has its own definitions and geographies.

Darkness, as it relates to architecture, is not the simple absence of light. It is not merely an empty space, nor is it perceived as a lack of effects. Instead, there is a tangibility to it - a weight and a presence. While light requires a mediation to be seen, darkness can exist alone. The experience is both aesthetic and sensation. When light is limited and darkness expands in space, geometries are heightened or masked, symmetries are obscured, masses are erased, color recedes or alters, material distinctions are muted, distances flatten, the air appears to thicken, and its occupants act differently. We fear it. And, for as powerful and bold as it is, darkness is a precious, fleeting and delicate existence.

Left out of conventional means of representation, there are numerous difficulties for architects to be designing with darkness. It is an aesthetic erasure, a sensed density, an intangible material quality, a subjective driver of fear, and in the case of night, a fleeting existence tied to astronomical orbits. Darkness points loudly to a disconnect between an architect's tools and the full actualization of materials and effects. There is a tuning to and

Image Hideout early test for east elevation.

Image Hideout early test for east elevation.

intangible effect that line weights cannot capture. Renderings can provide tone or mood, but cannot account for the adjustment of the eye over time, the sensation of being engulfed in the darkness, or the fleeting thickness of the emptiness. The effects of darkness task the attributes of the physical space with qualities impossible in full illumination: floatation, blurred edges, mutations, color alterations, and the ability to temporarily disappear. Only partially presenting a space and removing its greater context, darkness becomes an all-consuming micro-atmosphere that focuses the world down to its fading extents while simultaneously expanding its reach beyond visual comprehension. It is the immediate design of that which cannot be seen. It must be explored as an immediate environment, one that is of its own accord.

Its greatest power comes from being unexpected, uncontrollable, and presumably tied to a mischievous existence. Its presence, however, is necessary for understanding and intensifying our relationship to immediate spaces. It is productive to be afraid of the dark. Night reveals more than daylight; darkness reveals more than light. Darkness prompts an architecture in which the occupant is entirely present. The risk and reward is to allow darkness to collapse fear, imagination, and the city.

This presentation will demonstrate unexpected architectural results that only darkness permits. The presentation will focus primarily on one project, Hideout, a current work that is looking to add darkness to a hidden space. It will be supported by glimpses of previous works that have exposed the spatial and temporal effects permitted by a trust in darkness.

Catie Newell is the founding principal of the architecture and art practice *Alibi Studio and the Director of the Master of Science in Digital and Material Technologies at the University of Michigan. Newell is also an Associate Professor of Architecture at the Taubman College of Architecture and Urban Planning. Her research captures spaces and material effects, focusing on the development of atmospheres through the exploration of textures, volumes and the effects of light or lack thereof. Newell's creative practice has been widely recognized for exploring design construction and materiality in relationship to location, geography and cultural contingencies. Her work ranges in scale from buildings to products and explores the world by day and night with installations and photography. She is a Lucas Fellow, a Kresge Artist Fellow, and a Fellow of the American Academy in Rome.

Integrating Sound in Living Architecture Systems

Salvador Breed, Poul Holleman and Paul Oomen
4DSOUND, Amsterdam, Netherlands

We elaborate upon the results of collaboration between 4DSOUND and Living Architecture Systems Group throughout 2017 and 2018. It is argued that sound interweaves meaningful fabric to sculptural form and is a vital component of a living architecture. Sound is able to embed an architectural design within a perceived exterior sonic field, or sound can be embedded itself within the interior of the sculptural-architectural object.

Sound is an essential medium in understanding space, expressing emotions and abstracting organic and artificial phenomena. Architecture demands spatially and physically defined relations with sound. The in-depth collaboration between 4DSOUND and the Living Architecture Systems Group. has challenged to extend the possibilities to control sound within mediated worlds that seamlessly integrate the virtual with the actual.

The technological paradigm of 4DSOUND has evolved to regard sound by its sculptural and architectural qualities. Sounds are emitted from virtual objects of various shapes and dimensions, producing distinct resonance, reflections and physical behaviours. These objects are subsequently positioned in a virtually infinite space and can move following particular trajectories or in response to forces in the environment. A virtual environment responds to the presence of these sounds with acoustic reflections, modelled according to the dimensions and materiality of the room. These environments can take surreal forms as well, creating otherworldly textures and gestures that evoke imagination beyond the recognisable.

4DSOUND is an instrument, a set of tools that enable to compose and perform

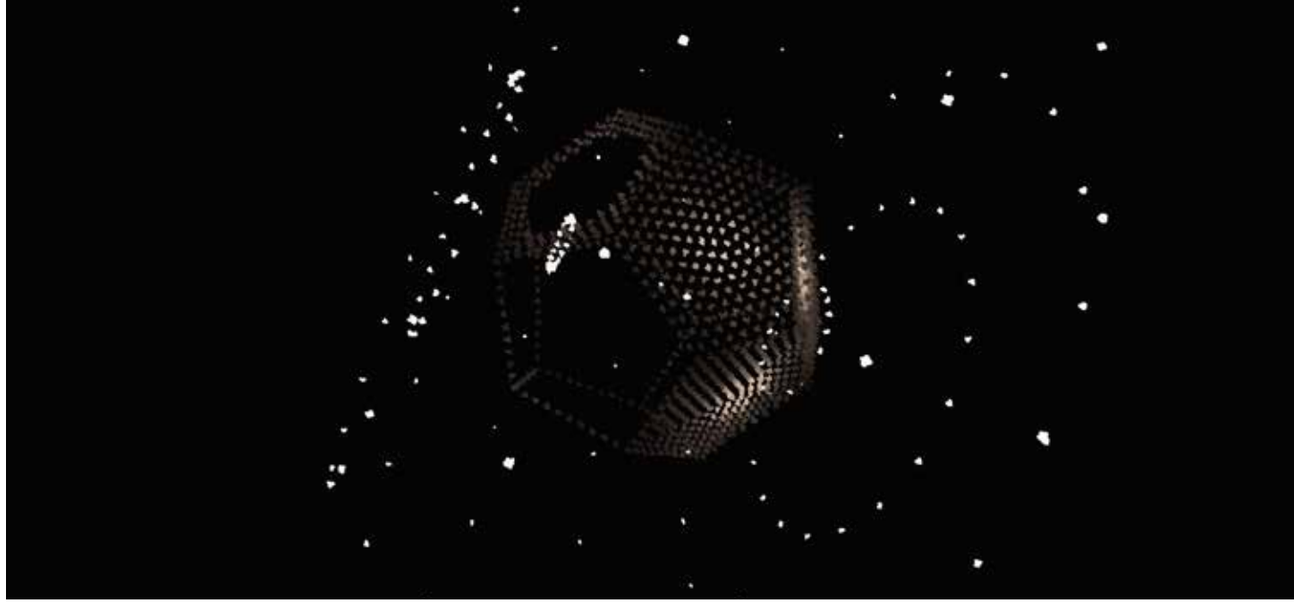

Image 4DSOUND Spatial Particle Body

with spatial sound intuitively and in great sculptural detail. A presentation of the present state of the technology will be followed by a testbed demonstration that shows some of the implementations in action that have thus far been realised within the context of the Living Architecture System Group. The challenge has been to not only create a virtual sound world that can be explored, but to embed this sound world in sculptural material and give actual objects a voice to further them being meaningful actors in a designed environment.

4DSOUND is a studio that explores spatial sound as a medium. Since 2007, 4DSOUND has developed integrated hardware and software systems that provide a fully omnidirectional sound environment. Building on more than a decade of research, development and experimentation with spatial sound technology, 4DSOUND has been at the forefront of realising some of the most creatively challenging and technically complex projects using spatial sound - ranging from symphonic experiences to bio-wearable instruments, from interactive theatre to kinetic architecture. In 2015, 4DSOUND founded the Spatial Sound Institute in Budapest - a permanent facility dedicated to spatial sound as an emerging field of study with increasing influence on a range of scientific, socio-cultural and artistic areas. The Spatial Sound Institute works with a diverse group of international collaborators to reframe the role of sound in artworks, interactions and relationship with the environment.

In Theoretical Physics
PB, IvH and the LASG

Michael Awad
Artist, Architect and Independent Academic, Toronto, Canada

What began as a simple photo essay of the LASG studio ended as a complex validation of:

- my earliest academic studies in physics,
- my ultimate academic investments in architecture,
- the unpredictable influence of technology on the creative arts,
- the primary role of simplicity in complex systems,
- the intimate connection between the natural and artificial worlds,
- the conceptual significance of basic research,
- evidence based predictions of future discoveries,
- the necessity of a slow search in a fast moving world,
- the importance of disciplinary interconnection,
- the need to ask questions without immediate answers,
- the latent potential of humble methodologies,
- the first meeting of Iris van Herpen and Philip Beesley,

and the power of visual time-based story telling.

Image Detail of Particle Physics, Michael Awad, 2019

Michael Awad is an artist, architect and independent academic. His experimental photography has shown at three public exhibitions: The PowerPlant (2001), the Art Gallery of Ontario (solo 2005) and the Royal Ontario Museum (solo 2014). His photographic commissions include the City of Toronto (currently displayed in Mayor John Tory's office), the York University Schulich School of Business, Pearson International Airport, Telus House, St. Joseph Communications, the ROM, the AGO, the Canadian Consulate of Chicago and The McMichael Gallery. In 2002 Awad's experimental urban photography was selected to represent Canada at the Venice Architecture Biennale. His university studies included theoretical physics, mathematics, computer science, architecture and urban design. He holds two professional degrees from the University of Toronto and one from Syracuse University. He has taught analogue & digital photography, video production, computer programming, robotics, media art and architectural design at the University of Toronto School of Architecture, and most recently, cultural planning policy in the School of Urban Planning at Ryerson University. Awad's public art has received a Toronto Urban Design Award in 2011; he has served on selection juries for all levels of government and is currently the Co-Chair of the InterAccess Media Art Centre.

chaosing into balance
.: *plenumophilic osmosis*

Navid Navab
Concordia University, Montreal, Canada

I maintain the view that computation is foremost a material process, non-linear, largely indeterminate, vibrant with life, and irreducible to deterministic models. Coming from this stance, how may we preserve the richness of uncanny processes while leveraging them compositionally? The act of composing computational media could entail the orchestration of event dynamics to quasi-deterministically enact degrees of instability and to enchant the stuff-of-the-medium. This process starts with an ethico-aesthetic search for the excitable mysteries of matter (material-energy-affective processes), and leads to a careful orchestration of sensuous moments of knowing with others, humans or none. A trippy conversation with nature if you may, or multi-sensory encounters with whimsical forces at the border of experimental arts, tabletop cosmology and natural fiction.

Image TangibleFlux Plenumorphic .: Chaosmosis Microcosm No.2 Plenumélliptique Périgée - Navab, 2018

Navid Navab is a Montreal-based media alchemist, multidisciplinary composer, phono-menologist, perSonifier, tabletop cosmologist, and gesture-Bender. Interested in the poetics of schizophonia, gesture and embodiment, his work investigates the transmutation of matter and the enrichment of its inherent performative qualities. He uses gestures, rhythms and events from everyday life as a basis for real-time compositions, resulting in augmented acoustical poetry and painterly light that enchant improvisational and pedestrian movements. Navab currently co-directs Topological Media Lab, where he leverages phenomenological studies to inform the creation of computationally-enchanted environments. His works, which take on the form of responsive architecture, site specific interventions, interactive scenographies, kinetic sculptures and multimodal performances, have been presented at diverse venues such as: Ars Electronica, Contemporary Arts Museum of Zagreb, Kapelica Gallery Slovenia, Canadian Center for Architecture, Festival du Nouveau Cinema, Shanghai eArts, MUMUTH Austria, HKW Berlin, Contemporary Arts Museum Houston, Digital Arts Biennial Montreal, Musiikin Aika Finland and milanOltre Festival Italy.

Being-in-the-Breathable
Field Work in Mobility and Atmosphere

Robert Bean
Nova Scotia College of Art and Design, Halifax, Canada

On July 23, 2017, Robert Bean and Barbara Lounder presented an annotated walk about breathing, human mobility and the politics of climate change. The interactive artwork responded to the contingencies of the sanatorium in Sokołowsko, Poland as a site of healing and conflict. Established by Hermann Brehmer in 1854, the sanatorium in Sokołowsko was the first centre in Europe for the climatic treatment of tuberculosis and was a significant precedent for other sanatoriums such as Davos, the site of *The Magic Mountain* by Thomas Mann. In addition to the mobile performance, Bean and Lounder installed an exhibition of related images in two of the abandoned patient rooms at the sanatorium. Allegorical references to the history of breathing, architecture, atmosphere, weather and healing were incorporated into the collective experience of being at the sanatorium.

Bean and Lounder begin from the position that walking is a creative medium and methodology. The history and contemporary practice of walking assert that it is a means to generate thought and knowledge through embodied experience. An active awareness of walking and mobility as a diverse and creative act cultivates an opportunity to consider a deeper comprehension

Image Sokolwsko Sanatorium, 2017

Image Sokolwsko, Poland, 2017

of environment and space. Walking is a sensorial experience; the senses provide both distilled and proximal relationships to the world that inform our knowledge and understanding of place. The ubiquity of technologically mediated space affects the experience of knowledge generation gained through walking. As pedestrians we are networked into multimodal sensorial experiences while walking and interacting with mobile devices.

For LASG, the first research question concerns the possibility of human mobility that is not defined by foundations, walls, infrastructure, borders or other containment systems controlled by nation states, designers or environmental contingencies. Can walking be considered as architecture in motion? The second question, regarding the Living Architecture Systems Group directive regarding organicism, intersects with theories of agential and speculative realism and the Anthropocene: who, or what, has the right to breath?

Being-in-the-Breathable considers the potential of an unbuilt environment within a context of human mobility, evanescent infrastructure and the formidable question posed by the prospect of anaerobic environments that recapitulate the deep time of organic evolution - a future without oxygen. Being-in-the-Breathable is a term that the author Peter Sloterdijk uses to describe how the atmosphere as an environment was made explicit by the use of gas warfare during the First and Second World Wars. The atmosphere, the last common space that humans share, lost its innocence when it was used as an environmental weapon.

Robert Bean is an artist, writer and curator living in Halifax, Nova Scotia. He is currently a Professor at NSCAD University. Bean has edited books and published articles on the subject of photography, human mobility, contemporary art and cultural history. He has been an active contributor to the Cineflux Research Group at NSCAD University and the Narratives in Space and Time art and mobility project. Bean is a recipient of grants from the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Canada Council for the Arts. In 2010, he was the Artist in Residence at the Canada Science and Technology Museum, Ottawa.

Robert Bean's work is in public and private collections, including the National Gallery of Canada, the Canada Council Art Bank, the Art Gallery of Nova Scotia, ZKM (Zentrum für Kunst und Medientechnologie) Karlsruhe, Germany and the Donovan Collection, University of St. Michael's College, Canada.

Biometrics in Participatory Collective Arts

Alan Macy
Biopac Systems, Inc., Santa Barbara, USA

In addition to our words, we express and observe "affect" when we engage with one another. We can think of affect as the measurable aspects of an always-running, body mobilization occurring within ourselves, subject to our flow of perceived experiences. Affect involves changes in heart rate, respiratory depth, pupil diameter, skin sweating, blood pressure, blood flow and vascular resistance, among numerous other physical shifts. Affect establishes our emotional / motivational state and creates the foundation for our ongoing judgement.

A project is introduced, "Biometric Campfire," that collects and utilizes affect data from a number of participants. Utilization is realized by the concurrent creation of a visual, tactile and auditory experience that is sourced from participant-generated affect. The Biometric Campfire is defined by the architectural space of a tensile structure (designed by Filum Ltd). Up to six participants sit down in a circle around a central light column, in chairs which measure their electrocardiogram (ECG) signals. Together, the participants will craft a creative expression — it may even represent a compositional unity, where the collective outcome is larger than the sum of its parts.

Image Biometric campfire

Alan Macy is currently the Research and Development Director, past President and a founder of BIOPAC Systems, Inc. He designs data collection and analysis systems used by researchers in the life sciences to help identify meaningful systems interpretations from signals produced by life processes. Trained in electrical engineering and physiology, with over thirty years of product development experience, he is currently focusing on psychophysiology, emotional and motivational state measurements, magnetic resonance imaging and augmented/virtual reality implementations. He presents in the areas of human-computer interfaces, electrophysiology and telecommunications. His recent research and artistic efforts explore ideas of human nervous system extension and the associated impacts upon perception. As an applied science artist, he specializes in the creation of cybernated art, interactive sculpture and environments.

Making Vibrant Matter

Live Matter
Live Agency and Design

Maria Paz Gutierrez
UC Berkeley, USA

Why is live matter in indoor building spaces and indoor microbiomes relevant for future building systems? In 1973, B.C. Wolverton et al. at NASA investigated a solution to maintain air quality in confined spaces, including space pods and homes. Wolverton and his research team demonstrated that indoor plants regularly remove pollutants from indoor spaces. The photosynthesis of plants and their roots, as well as other microorganisms, have the potential for actively breaking down contaminants. Since then, plants have been used in the form of living walls and biowalls in seminal projects such as the Guelph Humber Building. These projects have been developed to demonstrate the capacity of plants to act as biofilters for indoor air pollution.

Botanical filtration has been acknowledged, particularly, in the last decade as a beneficial method to reduce air contaminants in indoor environments through building systems as biowalls. While biowalls have demonstrated good potential for some air detoxification capabilities, they carry multiple complications. These include needing expansive volumes to require consistent maintenance to over-humidification and the use of water and potentially external energy inputs and mold growth which defies the basic aim of improving human health. The wide-range limitations and byproducts of plant-based biowalls have not been fully addressed to date.

Image 3D Printed Cork Waste Substrate with engineered Fungi. Photo by Maria Paz Gutierrez

Image 3D Printed Cork Waste Substrate with engineered Fungi. Photo by Maria Paz Gutierrez

Indoor air environment is composed of diverse communities exposed to multiple substrates at low concentrations and direct pollutant uptake. However, microorganisms have the distinctive potential of bio-based detoxification for buildings which can be carbon negative. Up to date, little is known of the potential of microorganisms and the interaction of construction materials with the microbiomes of the indoor and outdoor spaces. From microbial kinetics to surface reactions we have yet to explore the potential that live matter can bear for a radically new generation of construction materials that can be grown. In particular, microbiomes can bear a transformative potential for the engineering of live building blocks. The research here presented will address the potential that microengineered construction blocks made from organisms such as algae, fungi and lichen can carry for future indoor health.

Microorganisms such as fungi and lichen provide a unique opportunity for the necessary high volumetric capacity, surface reactivity while being zero water, zero energy and detoxifying multiple substrates and communities critical for relevant indoor air detoxification. Recent advances in detoxifying transgenes are also showing promise in biofilters. The research of BIOMS wwill present two investigations on live matter and its role in design agency from a biophysical and cultural framework. Detox Algae Membrane and the Lichen Microengineered block (collaboration with U. Colorado Living Architecture Group-W. Srubar and D. Rodrigues group at U. Houston) research will be used as a platform to address the domain of future indoor health.

Maria Paz Gutierrez is an Associate Professor and the Director of the Undergraduate Program of Architecture at UC Berkeley. Gutierrez is an architect and researcher whose focus is on nature and multifunctional material systems aimed at addressing pressing 21st century environmental and socioeconomic challenges. Gutierrez's research group BIOMS pioneers the biophysical and cultural implication of functional natural materials and living materials through multiscale digital fabrication and computation from nano to building scales. Her work has been published in leading scientific journals, including Science and Scientific Reports (Nature), exhibited nationally and internationally, and widely covered in the press, including in Science Nation. Gutierrez's prestigious accolades include being named a semifinalist for the 2014 Buckminster Fuller Award and receiving the 2010 Emerging Frontiers of Research Innovation Award from the U.S. National Science Foundation. She is a Fulbright NEXUS Scholar and served as an appointed Senior Fellow of the Energy-Climate Partnership of the Americas by the U.S. Department of State from 2011-2016. Gutierrez has two provisional patents and a forthcoming book Regeneration Wall.

Living Construction

Martyn Dade-Robertson
Newcastle University, UK

There has been a growing interest in the development of bulk engineered living materials which are intelligently synthesised and/or activated using microbial processes. At Newcastle University we have been developing a Bio Design Lab to investigate how we might develop these new type of materials for use in architecture. This research involves investigation into biominerals (the synthesis of mineral crystals to create new construction materials), biopolymers (for example, bacteria producing cellulose fibres and bioplastics) and responsive materials such as bacterial spore based hygromorphs (shape changing in response to water) materials. Our work also involves the integration of computer modelling across biology and engineering, advanced fabrication techniques (including 3D printing) and the physical testing of materials. Early research on this is being developed as part of the Bacterial Spore Hygromorphs project (seed funded through NCL) and the Computational Colloids and Thinking Soils projects (funded by EPSRC). Our presentation will give a brief overview of these projects and the work of our Ph.D. students, reflecting on themes, trends and directions for this research and the future of this area.

Martyn Dade-Robertson is the Reader in Design Computation at Newcastle University School of Architecture, Planning and Landscape. In addition to a degree in Architecture, he also has a degree in Synthetic Biology. Dade-Robertson's research group is investigating the application of Microbial Synthetic Biology Methods to develop new materials for Architectural Design. He is also the editor for the Routledge Bio Design book series, and the first in the series Living Fabrication will be out at the end of 2019.

Image Experimental apparatus to cement sand using microbial mineralisation. From Thora Arnardottir's Ph.D. work

Porøs
Phenomenon + Apparatus

Neil Forrest
Nova Scotia College of Art and Design, Halifax, Canada

Porøs is an installation of ceramic cisterns and circulatory elements rendered in porous ceramic media. In a topography of large vessels, some hold liquid, others distribute, filter and block, irrigate, and still others evaporate water. For me, these are objects to suggest distillation, archaeology, micro-climes and metamorphosis. The ceramic volumes are designed to mediate liquids in several ways and so become a narrative commodity, moving by passive means and from one state to another – liquid to gas, liquid to solid. Evaporation becomes part of the ceramic entities to modify the ambient air.

Porøs conflates architecture, craft and landscape. The architecture in Porøs – the datum or ramp – is provisional, and acts as a cropping tool to situate ceramic objects that move, filter and reveal liquids. Porøs follows the tradition of grottos as an artistic expression – caverns and sanctuary – and to the realm of basements, underground cisterns, trenches, ship interiors and bunkers for which an entirely different existential expression is to be found. Porøs is resolved as an inclined plane made of framed steel mesh units, bolted together and lifted off the ground – with objects that both pierce and sit under.

Image Porøs, 2014-2017, Stoneware & porcelain ceramics, solubles, wood, water pump, compressor, steel mesh, additional materials

Image Porøs, 2014-2017, Stoneware & porcelain ceramics, solubles, wood, water pump, compressor, steel mesh, additional materials

Water is part of both natural and mechanical systems. In two of the cisterns, liquid immures objects within. Other cisterns contain atomizing tablets – flat clay slabs constructed with internal channels so that liquid can be pushed into the tablets, and then forcibly squeezed through clay pores by the mechanics of compressed air and pressurized water. To the touch of a hand, the rapid percolation is a beautiful sensation. The tablets are a crux of the research…a clay formulation with unique aggregate that is consumed in the firing/hardening process to yield a microscopic pore structure. By pumps and compressors, a controlled air-water mix pushed through the pores creates an audible and visible effect – tiny amounts of water forming a continuous growth and exodus of bubbles. This hissing signals a microclimate at the surface of the tablets…the cluster of four cisterns contributing an environment of local humidity. Surplus water drains off the tablets into the four cisterns, is collected and cycled back to a single water reservoir at the anterior of the datum, to then resupply the pressurized tablets in a continuous loop. Porøs references chemical and earth processes of our geo-physical landscape. Natural soluble minerals efflorescing from wet rock faces and bricks whose surfaces accumulate scum (the 'free solubles' not locked in by flux in the clay matrix). In the installation, the idea is that solubles demonstrate the transfer of liquid and the state change of materials. Porøs also recalls the elemental ways that people have claimed materials such as salt from various vessels and methods: heated cauldrons, settling tanks and heated crucibles.

In Porøs, water-soluble chemicals evaporate and deposit crystalline formations and in turn, decorate their hosts. With the archetype of vessels, Porøs is a sensorium.

In his ceramic works, Neil Forrest examines the confluence of place, architecture and historical events which determine identity. He has collaborated with architects and engineers at the University of Buffalo, Boston Valley Terra Cotta and Dalhousie School of Architecture. His project Porøs at the ASU Art Museum in Phoenix/Tempe, is supported by the Norwegian Artistic Research Council. The research began with the porous nature of the clay itself and how porosity works as an expressive instrument. Other exhibitions include Overthrown at the Denver Art Museum, Ceramics and Architecture in The Netherlands, the Cheongju Biennale in Korea and Mobile Structures in Regina. Forrest holds a Masters from Alfred University and a BFA from Cranbook Academy.

Attuning Matter

Dana Cupkova
Carnegie Mellon University, Pittsburgh, USA

This presentation draws a connection between energy, human perception and living systems in architecture. Energy is both empirical and perceptual. Inspired by research on human emotional reactivity that can be mapped through temperature gradients of the human body, this presentation explores design through the passive thermoregulation of surfaces. My research explores the coupling of embedded conductors with strategically shaped surface geometry to modulate temperature. This research is focused on developing new forms of embedded material reactivity and biometric responsiveness of architectural surfaces that effect relationships between individual thermal comfort and energy usage.

The ambition is to develop new forms of communication between human perception and the built environment that combine passive and active systems to retune our awareness of temperature, emotiveness and human health. These ideas are central to my development of a thermochromically treated concrete that is thermally actuated by embedded electromechanical systems and can dynamically produce localized thermally reactive responses. This proposition extends directly to the design of environments by inciting thermal fields as active spaces that are attuned to the human psyche. Just like a "mood ring," this thermally reactive architecture would renegotiate a sense of individual and collective reflections in lieu of a singular spatial (and thermal) norm that represents an average measurement. Instead, I propose a functionality that attempts to produce spaces that respond to human diversity. Attunement in this regard requires a shift away from the data-driven rationales of performative models and the desire for design to tap into architectural sensorial subjectivity as part of the aesthetic and ecological experience.

Image Sentient Concrete prototype showing variation of surface color change due to temperatures induced internally by electromechanical controls and external heat dissipation

Dana Cupkova is a Design Director of EPIPHYTE Lab, an interdisciplinary architectural design and research collaborative. She currently holds Assistant Professorship at Carnegie Mellon University's School of Architecture and serves as a graduate program Track Chair for the Master of Science in Sustainable Design. She has been a member of the ACADIA Board of Directors since 2014-2018, and currently serves on the Editorial Board of The International Journal of Architectural Computing.

Cupkova's design work studies the built environment at the intersection of ecology, computational processes and systems analysis. In her research, she interrogates the relationship between design-space and ecology as it engages computational methods, thermodynamic processes, and experimentation with geometrically-driven performance logic. Her design work has been published internationally and presented at many academic conferences. In May 2018 Epiphyte Lab was recognized as the Next Progressives design practice by ARCHITECT Magazine, The Journal of The American Institute of Architects.

New Materials for an Era of Material Change

Mette Ramsgaard Thomsen
CITA, The Royal Danish Academy of Fine Arts, Copenhagen, Denmark

In this talk Mette Ramsgaard Thomsen will discuss how new interfaces expand and change the remit of architectural design. As architects become the designers of materials as well as of artefact, fundamental changes to our methods of design are posited. Ramsgaard Thomsen will outline these and discuss how these changes are important parts of challenging an industrialist perception of artifice and its relationship to environment as resource and as site. She will present examples of CITA's work as cases for these new emergent practices.

Mette Ramsgaard Thomsen is a Professor of Digital Technologies who leads CITA (Centre for Information Technology and Architecture) at the Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation. During the last fifteen years, her focus has been on the profound changes that digital technologies instigate in the way that architecture is thought, designed and built. In projects such as Complex Modelling and Innochain she is exploring the infrastructures of computational modelling, including open topologies and adaptive parametrization. She is pursuing design-led research at the interface of computational design and material thinking. Recent projects focus on advanced modelling concepts examining how machine learning and big data can become solutions for highly interdependent material systems. In 2016, she was awarded the Elite Research Prize for outstanding researchers of international excellence by the Danish Ministry for Higher Education and Science.

Image Isoropia, Venice Architectural Biennale 2018

4D Printing
Design and Dynamic Forms

Tim Miller, Ross Stevens and Bernard Guy
Victoria University of Wellington, New Zealand

Over the past six years researchers in the MADE group have been conducting 3D printing design experiments integrating the fourth dimension of time. Increasingly referred to as 4D printing[1] we will present two areas of enquiry: dynamic movement inspired by natural living systems and printing active metamaterials. As industrial designers, MADE's research goes beyond the pragmatic and explores the visual and emotive qualities these new forms of dynamic 3D printing can capture.

In 2012, Richard Clarkson designed Blossom, a field of interactive pneumatic flowers with dynamic petals as a manifestation of our growing interest in bio inspired multi-material 3D/4D printing. Multi-material 3D printing is achieved through the placement of digitally controlled blends of emulsified composite material, ranging in hardness from Shore A 27 to rigid material. Custom defined software and parametric 3D models aid the precise spatial distribution of the multi-property material within a singular 3D print, thus allowing the control of spatial and temporal transformation.[2]

Dynamic, expressive and emotive qualities were further expanded and refined in Lissom by Ross Stevens and Bernard Guy in 2015, which explored animation through Computer Generated Objects (CGO) rather than through time consuming Computer Generated Imagery (GCI). Skilful choreography brought a series of printed aquatic creatures to life. More recently

Image Interactive multi-material 4D print from Hydrophytes – tangible animation, Nicole Hone

this biological theme has been developed with increased sophistication by Nicole Hone in her Master's thesis project Hydrophytes – tangible animation. Here, 3D/4D printed aquatic plants are embedded with distinctive lifelike characteristics ranging from ethereal and playful to menacing and aggressive.

Metamaterials are synthetic composite materials with internal geometric structures that produce combinations of properties not found in naturally occurring materials.[3] Many reveal their hidden properties through movement, often exhibiting dimensional change in unexpected manners and directions. Since 2015, we have been considering the design opportunities these tunable materials present through geometric modification via parametric modelling and multi-material/multi-density printing. Most recently in 2018, Monique Bateman, in a project called 4D Materiality and Metamaterials, explored conceptual design solutions including a soft flexible safety helmet, as pentamode structures allow shear flexibility while retaining structural integrity. At the same time we took advantage of the fluid-like nature of the classic isotropic pentamode structure, configuring it to accommodate variations in the shape of the user's head. Using the pentamode's ability to divert sound waves, the helmet was designed to also cover the ears, thus having the potential to protect the user from damaging frequencies often associated with construction sites.
These projects have been made possible by MADE's research relationship with Stratasys and with the development of Voxel printing (a volumetric pixel or 3D pixel), where material properties can be defined digitally at an individual micro scale (pixel level). In combination with Artificial Intelligence, Voxel Printing presents new design opportunities for a greater synthesis between bio inspired and synthetic systems.

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Tim Miller is a Senior Lecturer at Victoria University of Wellington. He studied Product and Furniture Design, completing his Bachelor's honours degree at Kingston University London and his Master's in Industrial Design at UNSW Sydney. He has over 30 years of experience as an industrial designer, design consultant in product development, educator, and researcher in emerging technologies. His research exploits advances in digital technologies in the overlapping areas of digital manufacture, furniture design and 3D printing/Additive Manufacture. He has developed a number of innovative approaches in the use of software, digital manufacturing processes and 3D/4D printing technologies. Increasingly he works on collaborative projects with material scientists and engineers through his role as a Principal Investigator in the New Zealand Product Accelerator and leads projects for The Science for Technological Innovation Challenge, Portfolio 5 Materials, manufacturing and applications, Spearhead project, Additive manufacturing & 3D and/or 4D printing of bio-composites.

Research Exposed
Living Wall System Prototype

Petra Gruber
University of Akron, USA

The project Living Wall System (LIWAS) was an experimental design project to generate prototypes of wall systems integrating concepts from biology into architectural design. The “Living Wall” is a new way of interpreting a wall system as we use it in architecture and building. We try to integrate characteristics of living organisms into the wall design, so that we can harness some of the intriguing qualities of life into our built surroundings. Living Walls may include flows of water, may move, adapt geometry and change appearance, may be inhabited by algae, plants and other organisms and in general be “alive.” Biomimicry is used as a methodology for information transfer between the fields of architectural design and biological research.

Walls of buildings are especially interesting as they are borders between an interior environment designed for human habitation and a dynamic and changing outer environment. Active and multifunctional wall systems were

Image Mushrooms sprouting on mycelium material panel during the growth process

already proposed in the 1980s and negotiate between inside and outside, integrating functions such as energy management, light management, mechanical protection etc.

In an intensive design workshop in May 2018 the project team carried out a review of current literature and defined four specific goals that we wanted to incorporate into the new system.

Water management
- Harvest water from the environment for evaporative cooling
- Prevent fast runoff of rainwater to reduce sewage
- Living organisms

Create an environment for living organisms to settle
- Use living organisms to generate material systems
- Make use of living organisms for specific functions

Adaptation and change
- Design for change and adaptation
- Differentiated design to meet environmental conditions

Sustainable material use

The experiments took on experience of previous and current research on skins in biology, growth principles from biology translated to material systems, and how shape relates to thermodynamic functionality of plants.

Experiment Mycelium Wall (Thibaut Houette): we created a set of test panels made from mycelium material in the redhouse studio workshop in Cleveland. Mycelium material is based on agricultural waste such as straw, woodchips, sawdust or paper, that is solidified by the growth of fungal root systems, mycelium, into a lightweight material. In this set of experiments we want to test water resistance, efficient production of shapes by deforming the panels at a late stage of the growth process, degeneration process of the material when left outside, and the use of the panels as a façade cladding.

Experiment Evaporative Wall (Ariana Rupp): we created 3D surface morphologies based on the edge geometry of plant leaves in Drew Ippoliti's ceramics studio at Myers School of Art. Plants make use of water evaporation to manage both internal metabolism and thermal requirements like cooling. The shape of leaves plays a role in the evapotranspiration capacity. Abstracted designs are translated into 3D surface geometries of ceramic panels. The porosity of the panels should allow for evaporation of water guided through a façade system.

The final prototype was installed and presented at the Biology field station at the Bath Nature Preserve in Fall 2018.

Petra Gruber is an architect working with inter- and transdisciplinary design. She holds a Ph.D. in Biomimetics in Architecture from the Vienna University of Technology in Austria and collaborated as a research fellow at the Centre for Biomimetics at The University of Reading, UK. Gruber taught Biomimetics in Energy Systems at the University of Applied Sciences in Villach, Austria and held lectures and workshops at universities worldwide. As a visiting professor for Architectural Design and Building Science, she set up a Masters program in Advanced Architectural Design at the Addis Ababa University in Ethiopia.

Gruber's research spans from projects for the European Space Agency on lunar base design informed by folding principles from nature to arts-based research on the translation of growth principles from nature into proto-architectural spatial solutions. Since 2016 she has been with the Biomimicry Research and Innovation Center BRIC at The University of Akron.

Feasibility Fueled Experimentation

Michael Fox and Juintow Lin
Cal Poly Pomona, Pomona, and FoxLin Architects,
San Clemente, USA

Image Gesturally Controlled Interaction, CPP

The technium as coined by Kevin Kelly in 2010 is a superorganism of technology. It is all-encompassing and interconnected and both influences and is influenced by our endeavors. While there have always been technological advancements, the advancements specific to the tools used in the profession of architecture are relatively recent. Only one generation ago was the first to adopt computers, displacing the analogue tools (and consequently many of the processes) that had been used for centuries. The adoption ensnares a continual advancement in the processes we use to design, visualize, document, incorporate data into, conceptualize, fabricate and construct architecture. As technology advances we are finding that the one thing that never changes is that the tools are constantly changing. As new tools come to the fore, so do new processes, and it is critical to understand both the desired outcome and the processes over the skills required to use tools themselves. Learning to learn requires an adaptive and flexible mindset with regards to all tools in the future. It is important to understand that the processes, the designs and the built artefacts are tied directly to the tools. As new tools come to the fore, so do new processes and consequently new built forms and new capabilities of built form.

We are now at a time where both an increased aptitude to integrate computational intelligence into our buildings and the economics of obtaining affordable computational hardware have become accessible to architects. Although the foundations of computationally integrated architecture (responsive, intelligent, interactive, dynamic etc.) stretch back to the theoretical work of cyberneticians half a century ago, it was not until the early 1990s that architectural projects began to relish the newly available technological advancements of the time. It was a commencement for when wireless networks, embedded computation and sensor effectors became both technologically and economically feasible to implement. This feasibility fueled experimentation with many of the ideas that had been previously stifled by the technological and economic hurdles of their day. We are now finally seeing an explosion of current exploration due to the influence of feasibility within our technium.

The relativity of recent technium advancements on interactive architecture has placed us in a unique position to reposition the role of the designer. The role of the designer should be not so much to create a finished design as to catalyze a design, to ask that it may evolve. In a sense, designing interactive architecture should be an ego-less, emergent endeavor that lies in not designing the future, but designing the platform for the future. Such a position is both noble and profound, for it means the designer must understand people well enough to not only design for them but to design the interfaces and tools for them so that they in turn can become designers. It has become a catalyst for design and ideas that were never intended.

Such a catalyst defines “architecture as an interface” which allows users to directly interact with the environments in undefined ways. The technium has allowed designers to create malleable works which can evolve, and has allowed users with the capacity, aptitude and capability to play a consequential role in the evolution. Such interaction, or “play,” with the pvhysical world is crucial to the way we learn to socialize and understand our reality.

Michael Fox is a founding principal of FoxLin Architects. Prior to FoxLin, he served as an assistant to engineer and inventor Chuck Hoberman in New York and as a design team leader for Kitamura Associates in Tokyo, Japan. In 1998, Fox founded the Kinetic Design Group at MIT as a sponsored research group to investigate interactive architecture, which he directed for three years. He is the author of the books Interactive Architecture, and Adaptive World, both published by Princeton Architectural Press. His practice, teaching and research are centered on interactive and bio-mimetic architecture. He has won numerous awards in architectural ideas competitions. Fox’s work has been featured in many international periodicals and books, and he has lectured and been exhibited worldwide. He has taught on the subject matter of interactive, behavioral and kinetic architecture at MIT, the Art Center College of Design in Pasadena, and SCI_ARC in Los Angeles. He is a Professor of Architecture at Cal Poly Pomona, a regular visiting professor at The Hong Kong Polytechnic University and the past President of ACADIA. Michael studied Architecture at the University of Oregon and received a Master of Science in Architecture from MIT.

Juintow Lin is a Professor at Cal Poly Pomona, where she teaches courses on sustainability, design, constructionand technology. Juintow is a registered architect and founder/ principal of the award-winning firm FoxLin Architects. She is involved in all aspects of projects as both manager and designer. Prior to co-founding FoxLin, she worked for Foster & Partners in London and Pei Cobb Freed & Partners in New York. Lin received both her undergraduate and graduate degrees from MIT. She also served as a Research Fellow at MIT, working on Sustainable Urban Housing in China, and co-edited and co-authored a book of the same title in 2006. She was a pioneering member of the Kinetic Design Group at MIT, investigating the design and application of behavioral kinetic systems in architecture.

Image The one with the arm: Tactile Catalyst Design, Bubbles, FoxLin Architects

Knit, Wound, Woven

Recontextualizing Architectural Typologies and Assemblies through Fibrous Composites

Andrew Wit
Temple University, Philadelphia, USA

If buildings were to be knit, wound or woven, what form would they take and what types structural, spatial and ephemeral attributes would arise? What would they feel like to the touch or to inhabit? What novel materials and methods would be necessary for this emergent typology of production to arise? Additionally, how could these novel typologies of form, space and texture redefine the relationship of architectural space and artifacts with their inhabitants and surrounding environment?

This presented research, viewed through the lens of several case studies will discuss how the integration of fibrous materials such as Carbon Fiber Reinforced Polymers (CFRP) has the ability to alter our perception of, the purpose of, and the future potential for the discourse of architecture. The research looks beyond mere material/ financial efficiencies typically associated with computation, optimization and building, and attempts to push architecture beyond the embellished shelter and into an emerging realm where buildings act as agents within the environment, redefining how we view, interface with and inhabit architectural space.

Image cloudMAGNET, by Andrew John Wit + Rashida Ng

In architectural design, materials, processes, tools and form are intimately connected. Form, space and the artifact's visual, tactile and ephemeral qualities at the scale of architecture are defined and perhaps limited by the existing pallet of materials, tools and processes available to and desired by architects. Unlike other tangential design disciplines such as automotive, aeronautics, prosthetics and personal technological devices where novel non-standardized composite materials may be engineered, tested and immediately implemented directly into their creation, architecture tends to reside in the past. Tied perhaps by nostalgia or a resistance to change to a pallet of outdated, inefficient and rigid materials and processes, the discipline of architecture finds itself lagging behind in its ability to conceive novel forms and spaces that redefine how users interact with the built artifacts.

Through a series of continually evolving case studies, this presented research investigates the creation of new typologies of architectural form, space and structure achieved through the integration of fibrous CFRP based systems. rolyPOLY[1] is manifested through a series of prototypically woven, aggregating porous shells. These shells, structural in all configurations, create new typologies of architectural texture and sensate environments though the patterning of thickened weaving and winding; cloudMAGNET[2] is a series of cloud-making kites developed through a flexibly wound, multi-material tension-based CFRP system. Paired with a phase change embedded tensile skin, this project attempts to redefine how climate active spaces interface the environment; COMPRESSED[3], derived through 3D Graphic Statics, acts as a wound, multi-layered, compression-only structural system. This project tests the limits of fibrous composites as a flexible system under extreme structural stresses. Finally, The Tipping Table[4] is a multi-layer, spatially woven hybrid tension/compression system that expands previous research by magnifying how we visualize structure in larger-scale, minimal material structures. Through a discussion around these projects, this presentation attempts to recontextualize architectural typologies and assemblies through fibrous composites.

References

1 Research with Simon Kim; 2 Research with Rashida Ng; 3 Research with Masoud Akbarzadeh; 4 Research with Masoud Akbarzadeh

Andrew John Wit is an Assistant Professor at the Tyler School of Art, where he leads research focusing on novel building systems generated through composites, emerging tools and robotic systems. Additionally, he is a co-founder of the interdisciplinary research group wito* "Laboratory for Intelligent Environments" and a co-editor of the book Towards a Robotic Architecture, and the ACADIA 2018 RECALIBRATION ON IMPRECISION AND INFIDELITY projects and paper proceeding books. Wit is an elected member of ACADIA's board of directors where he chairs the scientific committee. He is also an associate editor for the Construction Robotics journal, co-guest editor for a forthcoming issue of the Architectural Science Review, and serves on the editorial board for the International Journal of Architectural Computing. Wit's research and projects have been highly recognized at UTenSAils (2007 AIA Best of Practice Award), the Advanced Fabrics Exhibition (2007 IFAI Outstanding Achievement Award), along with the widely-published Underwood Pavilion and woven carbon fiber installations rolyPOLY and cloudMAGNET. Wit's work has been featured at numerous galleries, international conferences and refereed publications. Wit received an M.Arch from the Massachusetts Institute of Technology and a BS in Architecture from the University of Texas at San Antonio.

Hybrid Nature

Botanical Fur

Carole Collet
Central Saint Martins UAL, London, UK

Image Botanical Fur studies, Cephalocereus Senilis. Photo by Carole Collet

The textile and plant worlds have been intrinsically linked throughout our history. Deriving materials, threads and fabrics from plants such as cotton, flax, or even from agave plants and tree bark have been historically linked to our evolution and ability to transform our environment to evolve a purpose-built everyday materiality. Equally, the manipulation of plant architecture is linked to our agricultural and horticultural history, where intersecting species and breeding techniques have led to the on-going and competitive development of new plant cultivars. Whilst the production of fibres and cloth and the development and control of plant systems are a rich context of reference, the current ecological paradigm sets a new scene to research and prototype original textile constructs that are mindful of our limited natural resources. The Botanical Fur research project is an enquiry into the plasticity and morphogenetic control of fur-like botanical systems and is concerned primarily with plants' ability to grow fur. Whether located on roots, stems or leaves, trichomes (i.e. plant hairs) provide a range of functions such as defence against pests, adaptation to temperature and climate change, protection and biosensing.

Whilst these biological functions are a result of evolution, 'new insights are emerging on fundamental aspects of the plasticity development – a phenomenon unique to plants and therefore chartering new territory not encountered in animal or microbial systems.'[1] The project asks: what can we learn from plants' fur systems that can inform new textile fabrication methods? Can we harvest plants' fur for biofabrication purpose? Can we genetically control the mechanics and architecture of plants' roots and trichomes to grow textiles? This research project explores biological functions in plants' systems to prototype new textile conceptual constructs and new material assembly techniques.

The project is structured around three phases of research.

Phase 1 explores the plasticity and tactility of natural plant fur such as produced by *Cephalocereus Senilis*, a species of Cactus originating in Mexico, to create a range of miniature fur textile samples.

The second phase of the project intersects plant tissue engineering techniques with textile patterning methods to grow textile-like root assemblies in vitro.

The final phase (pending funding) will research plant synthetic biology techniques to control the characteristics of root hair and colour. Phases one and two will be presented at the exhibition 'Les Fabriques du Vivant,' Pompidou Centre, Paris, February 2019.

References

1 Ed. Plant Architecture and its manipulation. Annual Plant Reviews, Volume 17. Blackwell Publishing. P. 13.

Carole Collet is a Professor in Design for Sustainable Futures at Central Saint Martins, University of the Arts London, where she currently holds two key roles. As the CSM-LVMH Director of Sustainable Innovation, she set up Maison/0, an incubator of creative sustainable innovation, in partnership with the luxury group LVMH. She is also the Director of the Design & Living Systems Lab, a research lab which explores the interface of biological sciences and design to propose new sustainable models of biofabrication. As an educator, she has pioneered the integration of sustainability in the curriculum by creating new courses such as the MA in Textile Futures in 2001 (now Material Futures) and more recently in 2018 the first MA in Biodesign. Collet's research questions the emerging role of the designer when working with biological systems. She has also established an original framework for sustainable biodesign, which was first published with the inaugural curation of 'Alive, New Design Frontiers' in 2013. Collet's work has been featured in international exhibitions. She also regularly contributes to conferences on the subjects of biodesign, biomimicry and sustainable futures.

Image Botanical Fur Studies, Eposta Melanostele. Photo by Carole Collet

flora robotica

Investigating a Living Bio-Hybrid Architecture

Phil Ayres
Royal Danish Academy of Fine Arts, Copenhagen, Denmark

The objective of the flora robotica project is to investigate closely linked symbiotic relationships between living plants and robots for the purpose of growing architectural artifacts and spaces.[1] To achieve this aim, a cross-disciplinary consortium of six partners has been assembled, drawing together expertise in Architecture (CITA at the Royal Danish Academy of Fine Arts), Computer Science & Swarm Robotics (University of Lübeck), Artificial Life & Biology (University of Graz), Artificial Evolution & Robotics (IT University, Copenhagen), Sensing & Mechatronics (Cybertronica Gmbh) and Molecular & Cellular Biology (Adam Mickiewicz University).

The architectural motivation underlying the project is to help lay principled foundations for radical and potentially disruptive alternatives to current paradigms of resource intensive construction by harnessing the capabilities of living systems - specifically plants, and their capabilities for material sourcing, resource distribution, adaptation, decision making and self-repair.

However, the incorporation of living complexes as an integral part of an architectural fabric (rather than conceptualised as supplementary layers to conventional construction) remains an under-investigated area. It also poses significant challenges to orthodox approaches of architectural representation and construction, as well as broadly accepted cultural understandings of what architecture ought to be. For example, notions of architectural 'completion' require revising to accommodate processes of continual growth and adaptation throughout a 'growth career'; pre-defined and projected architectural objectives (and the courses of action derived to achieve them) need to be continually monitored, evaluated, steered and/or modified in relation to actual circumstances; construction, considered as a discrete phase of architectural production and predicated upon a predetermined inventory of parts, must be re-conceptualised as a continuous process across a life-cycle in order to incorporate the continual flux of material resulting from self-organising processes with seasonal dependencies.

Our investigations have focused on the use of decentralised control paradigms to steer natural growth in living plants using bespoke distributed robotic devices[2] and implementing artificial growth of scaffold systems using the novel Vascular Morphogenesis Controller (VMC) in concert with robotic construction devices.[3] The use of scaffolds follows state-of-the-art bio-hybrid architectural approaches demonstrated by Baubotanik, and historical design precedents by Wiechula or Gaucher at the turn of the 20th Century and Küffner at the turn of the 18th Century. It also follows conventional horticultural practice for climbing plant species. In architectural terms, the scaffold permits spatial delineation and organisation in advance of anticipated growth. In practical terms, the scaffold provides mechanical support for young, maturing plants. The novel contribution of the flora robotica project to the methodology of scaffolding is to couple morphologically and mechanically flexibility with capabilities of artificial growth and adaptation. We achieve this by using braid and weave logics – and combining them with the VMC.

In addition to the engineering-focused efforts of developing appropriate and robust hard/software for various control and fabrication functions, a principle architectural task is to develop a spatial vocabulary that articulates the underlying characteristics and properties of a plant/robot bio-hybrid architecture. This vocabulary also aims to give expression to the productive tensions that exist in the coupling of self-organised processes with design intention. Like a form of garden, this heterogeneous spatial vocabulary is poised between states of the cultivated and the wild, the growing and the grown, the fixed and the indeterminate, the abundant and the sparse, the living and the deceased.

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3 Hofstadler, D.N., et al. "Artificial Plants - Vascular Morphogenesis Controller guided growth of braided structures."; Zahadat, P., et al. "Vascular morphogenesis controller: a generative model for developing morphology of artificial structures." In: Proceedings of the Genetic and Evolutionary Computation Conference. ACM, 2017. p. 163-170

Phil Ayres is an architect, researcher and educator. After a decade of teaching and researching at the Bartlett School of Architecture, UCL, Ayres joins the Centre for Information Technology and Architecture (CITA) in 2009 as an Associate Professor. The primary focus of Ayres' research is on adaptive architectural systems that integrate technical and organic elements with the development of complementary design environments. Ayres is currently undertaking flora robotica - an EU funded project of which Ayres is the Principle Investigator. Ayres teaches at Masters and Ph.D. levels and he is also the Editor of the title Persistent Modelling: Extending the Role of Architectural Representation published by Routledge in 2012.

Image Anders Ingvartsen/CITA/flora robotica

Monarch Sanctuary

Mitchell Joachim
Terreform ONE and NYU, New York, USA

Our mission is to design against extinction. The monarch butterfly of North America is a species at risk. The U.S. Fish & Wildlife Services is currently assessing whether the monarch needs to be granted "endangered species" status, while the monarch population erodes due to the combined forces of agricultural pesticides and habitat loss. Monarchs are a delicate presence in New York City.

Monarch Sanctuary will be eight stories of new commercial construction in Nolita, NYC. Central to its purpose is serving as a breeding ground and sanctuary for the threatened monarch butterfly. It aims to be socio-ecologically robust, weaving butterfly conservation strategies into its design through the integration of monarch habitat in its façade, roof and atrium. Not just a building envelope, the edifice is a new biome of coexistence for people, flora and butterflies.

The double-skin street façade, with a diagrid structure infilled glass at the outer layer and with "pillows" of ETFE foil at the inner layer, encloses a careful climate-controlled space, 3' deep. This "vertical meadow," the terrarium proper, serves as an incubator and safe haven for Monarchs in all seasons. It contains suspended milkweed vines and flowering plants to nourish the butterflies at each stage of their life cycle. Hydrogel bubbles maintain optimal humidity levels, and sacs of algae purify the air

Image Close-up view of cable suspended nectar hubs for butterflies and enclosed milkweed growing chambers for caterpillars

and wastewater. LED screens at the street level provide magnified live views of the caterpillars and butterflies in the vertical meadow, which also connects to a multi-story atrium.

The building is intended to serve as an object lesson in enhancing the urban environment with green technologies, including plant life and other creatures, in designing for other species, and in conveying images of new possibilities for the urban environment. This project alone will not save the Monarch but it will crucially raise awareness about our much-loved insect residents.

Mitchell Joachim is co-founder of Terreform ONE and an Associate Professor at NYU. He was formerly an architect at Gehry Partners LLP and Pei Cobb Freed. He has been awarded a Fulbright Scholarship and fellowships with TED, Moshe Safdie and Martin Society for Sustainability, MIT. He was chosen by Wired magazine for "The Smart List: 15 People the Next President Should Listen To." in 2008, Rolling Stone magazine honored Joachim in "The 100 People Who Are Changing America." He has won many awards including: AIA New York Urban Design Merit Award, Victor Papanek Social Design Award, Zumtobel Award for Sustainability, Architizer A+ Award, History Channel Infiniti Award for City of the Future, and Time Magazine

Best Invention with MIT Smart Cities Car. Dwell magazine featured him as “The NOW 99” in 2012. He co-authored three books, XXL-XS: New Directions in Ecological Design, Super Cells: Building with Biology, and Global Design: Elsewhere Envisioned. His work has been exhibited at MoMA and the Venice Biennale. He holds a Ph.D. from Massachusetts Institute of Technology, MAUD from Harvard University, M.Arch from Columbia University.

Monarch Sanctuary Team
Project Management: Vivian Kuan.
Designers: Christian Hubert, Nicholas Gervasi, Maria Aiolova, Anna Bokov, Kristina Goncharov, Yucel Guven, Zhan Xu, Larissa Belcic, Shahira Hammad, Deniz Onder, James Leonard, Zack Saunders, Xinye Lin, Sabrina Naumovski, Daniel S. Castaño, Aidan Nelson, Aleksandr Plotkin, Kristian Knorr, Sophie Falkeis, Rita Wang, Michael Brittenham.
Tech Consultant: Anouk Wipprecht

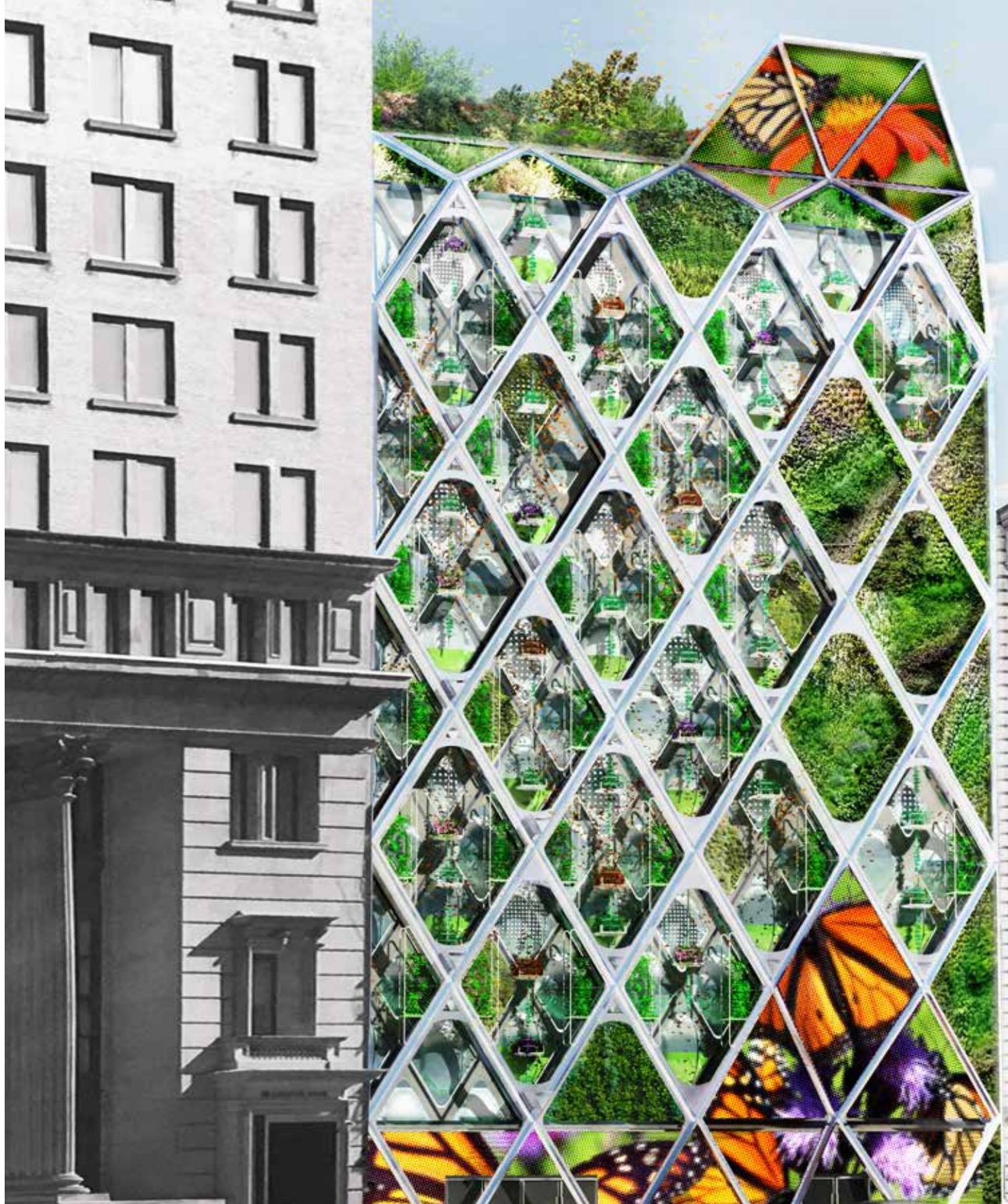

Image Monarch Sanctuary Mockup

Wild and Domestic
Architecture and the Nonhuman

Andrew Kudless
California College of the Arts, Oakland, USA

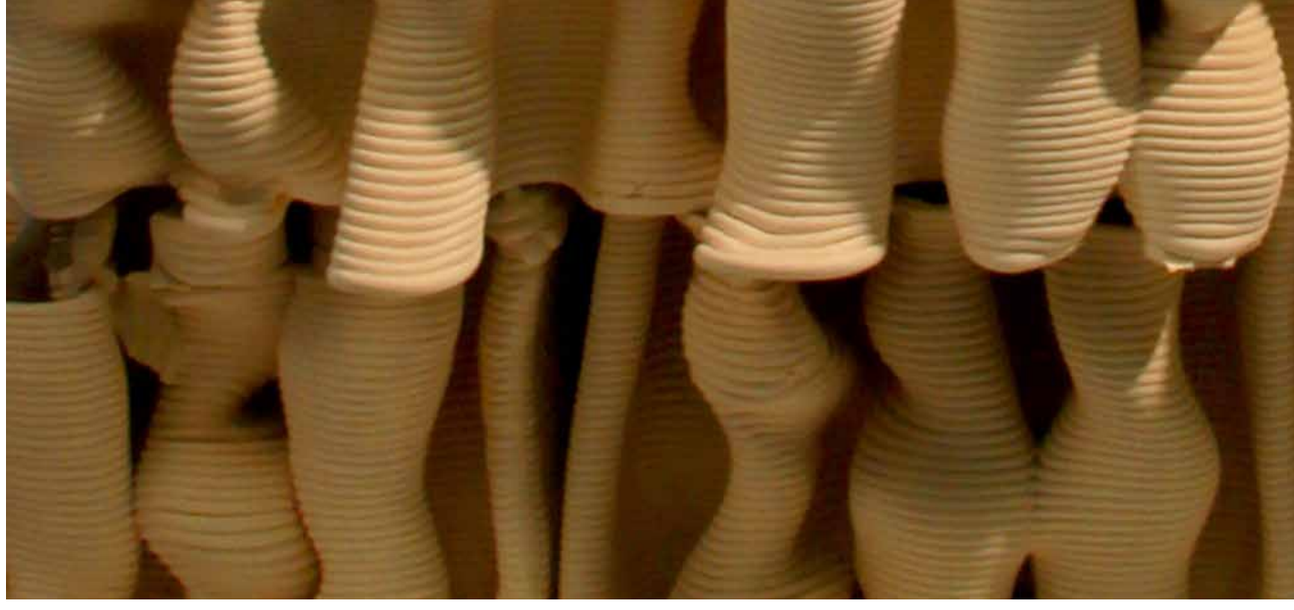

Image Detail of 3D printed ceramic brick wall designed to facilitate the dwelling and protection of the Long-nosed Bat in agave fields of Oaxaca, Mexico by California College of the Arts student Maya Annotti.

The various creation myths of architecture often alternate between early humans either occupying found forms such as caves or constructing a primitive hut. Vitruvius mentions both of these possible origins for architecture but he also mentions a third origin which is often forgotten: maybe humans first started building by watching more advanced builders: animals. Although we often think of architecture as a human activity, the diversity and sophistication of animal architectures is astounding. From wasp nests to beaver dams, animals have developed highly complex domestic spaces that often surpass the material, environmental and structural performances of human-built forms. These nonhuman architects use a variety of materials such as straw and wood; however, many use earthen materials such as soil, mud and clay to 3D print their homes.

We will use this alternative history of architecture as a starting point and source of inspiration on how we, as human architects, might conceive a different way of designing, building and occupying domestic forms in solidarity with the nonhuman world. The presentation will focus on a number of recent studios working with architecture, design and art students at the California College of the Arts on the ecology, design and construction of human and nonhuman dwellings.

The human act of building for animals has a long architectural history primarily centered on transactional exchanges between species. From bee apiaries and dovecotes to silkworm cocooneries and dairy barns, humans have been creating structures for nonhumans for centuries in order to benefit from these creatures: foods such as honey, eggs and milk but also raw materials such as silk and even less tangible exchanges such as heat and companionship.

However, urbanization and industrialization have increased the physical and conceptual distances between humans and nonhumans. Furthermore, the way in which contemporary architecture engages the nonhuman world could generally be categorized into total rejection (pests), reduction (sustainability's focus on energy) or benevolent separation (the picturesque). This presentation will look beyond these and attempt to discover (or rediscover) other ways of living with the nonhuman, especially species that have a commensal relationship with humans.

In an age when we are finally recognizing the extent of our deep relationships with the environment around us and the microbiome within us, we seek a form of solidarity with the nonhuman. Our research focuses

Image Detail of 3D printed ceramic brick wall continued

on how architecture might serve as the medium to reevaluate the politics, cultures and ecologies of living near and with other species. Students were encouraged to develop radical approaches to the siting, programming and ecologies of their domestic designs in relation to both human and nonhuman clients. The work envisions different forms of domesticity that reengage humans with the messy and complex reality of living together.

Andrew Kudless is a designer based in San Francisco, where he is an Associate Professor at the California College of the Arts. In 2004, he founded Matsys, a design studio exploring the emergent relationships between architecture, engineering, biology and computation. He holds a Master of Arts in Emergent Technologies and Design from the Architectural Association and a Master of Architecture from Tulane University. The work of Matsys has been exhibited internationally and is in the permanent collections of the San Francisco Museum of Modern Art, the Centre Pompidou in Paris and the FRAC Centre in Orleans, France.

Synthetic Cognition

Learning Through Interaction

Dana Kulić
Monash University, Melbourne, Australia

Can architectural environments provide an engaging and empathetic interaction with occupants? In this talk, I will describe our ongoing work within the LASG synthetic cognition stream to develop systems that learn to engage visitors through interaction. I will briefly review our earlier work investigating curiosity as an intrinsic motivator for learning. Then, I will describe our recent work examining measures of engagement as extrinsic motivations for learning. In this work, we use the sensors available within the living architecture system to develop a measure of group engagement, and use this measure as a reward to maximize learning. We investigate how behaviours designed by the architect can be used to bootstrap learning. The system was recently tested at the *Transforming Space* exhibit at the Royal Ontario Museum in Toronto, Canada. We found that visitors exhibited increased engagement with the learning system and reported it to be more likeable and interactive.

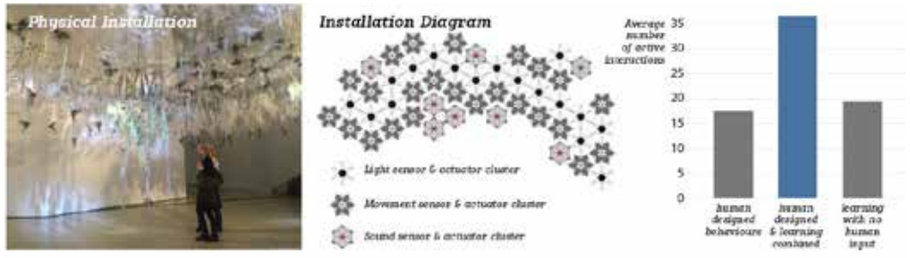

Image Learning with user-guided action abstraction. This image illustrates how human teachers and learning agents can work together to improve performance over what either can do alone. The learning system (embedded in the physical installation shown on the left panels) uses human-designed action abstraction and learns how to best engage visitors during interaction. The results (right panel) demonstrate significant increases in active interactions when human teaching and robot learning are combined.

Dana Kulić received the combined B.A. Sc. and M.Eng. degree in electro-mechanical engineering, and the Ph.D. degree in mechanical engineering from the University of British Columbia, Canada, in 1998 and 2005 respectively. From 2006 to 2009, Dr. Kulić was a JSPS Postdoctoral Fellow and a Project Assistant Professor at the Nakamura-Yamane Laboratory at the University of Tokyo, Japan. In 2009, Dr. Kulić established the Adaptive System Laboratory at the University of Waterloo, Canada, conducting research in human robot interaction, human motion analysis for rehabilitation and humanoid robotics. Since 2019, Dr. Kulić has been a professor at Monash University, Australia. Her research interests include robot learning, humanoid robots, human-robot interaction and mechatronics.

Sensibilities of Artificial Intelligence

An Examination of Architecture in a Posthuman Design Ecology

Matias del Campo
University of Michigan, Ann Arbor, USA

The sad thing about artificial intelligence is that it lacks artifice and therefore intelligence.
– Jean Baudrillard

In recent years an entire plethora of projects claimed to have created the first AI poem. A simple Google search for "AI poem" reveals about 30 million results, with a different degree of scientific credibility. I remember recently hearing one of those poems, which posed the thought: It might be AI generated, but is it good poetry? A question that immediately digs into a current major question in regards of the application of Artificial Intelligence: Can AI be creative? First and foremost this means that it is necessary to understand what creativity is and how it can be replicated in a set of rules and algorithms. For the sake of the conversation in this presentation I will provide one among various definitions of creativity, which is the ability of the human mind to find unusual solutions within a set of normative rules - the ability to create cross-connections, and the ability to find advantages in mistakes. Mis-interpretations, and mis-readings can result in highly creative solutions. How can this be translated into a system in architectural design? How does it affect architectural design at large? In order to examine this idea we set out to demonstrate a methodology of design which interrogates aspects of Artificial Intelligence. The presented project, *La chapelle des machines*, discusses the design technique itself as well as the underlying aspects of aesthetic, ethics and existence.

La chapelle des machines demonstrates in a provocative fashion the multitude of lenses of observation for a problem like Artificial Intelligence and Architecture. Not only as a toolset to optimize very specific elements of architecture such as floorplan, material consumption and structure, but rather to emphasize architecture's ability to serve as a cultural marker and place of worship. To that extent it proposes a position that radically challenges the idea of computational methodologies as tools of expediency and efficiency and embraces the possibility to use it as a tool of communication between the human mind and an, as of this date, alien intelligence (alien in the sense of defamiliarization or estrangement). Following intense conversations in the office about the nature of AI, and its possible impact on architecture, *La chapelle des machines* started speculating about the various possible aesthetic conversations possible through the use of AI.

The main question was whether an AI could create a novel sensibility based on specific datasets, and how human intervention could steer the results, thus exploring possibilities for a human/AI collaboration. Sensibility is understood here in the sense of a novel aesthetic approach to architectural solutions. This project was negating the abilities of AI to optimize solutions, a problem that has been well explored within the realm of machine learning and architecture, but instead, the focus of this research was on the aspects of cultural agency outside the frame of human intervention. In this sense the project intentionally flirted with ideas of a posthuman world in which cultural agency occurs outside an anthropocentric universe.

Matias del Campo is a registered architect, designer and educator. Founded together with Sandra Manninger in Vienne 2003, SPAN is an international practice best known for its sophisticated application of contemporary technologies in architectural production. Its award-winning architectural designs are informed by advanced geometry, computational methodologies and philosophical inquiry. SPAN describes this frame of considerations as a design ecology. Most recently Matias del Campo was awarded the Accelerate@CERN fellowship, the AIA Studio Prize and was elected into the Board of Directors of ACADIA. He guest edited an edition of AD, Architectural Design. SPAN's work is in the permanent collection of the FRAC, the MAK in Vienna, the Benetton Collection, and the Albertina.

Image La chapelle des machines (SPAN 2019)

Toward Playful Intelligence in Shared Reality

Haru Ji and Graham Wakefield
OCAD University and York University, Toronto, Canada

We present ongoing developments of infusing environmental spaces with near-living behaviour through recent works in the Artificial Nature series, including *Conservation of Shadows*, *Insuperposition*, and *Infranet: Gwangju*, and the ways in which key elements of these works are converging to new propositions. We focus on the use of mixed reality (VR, AR and motion capture) as a method of shared physicality in hybrid space between human and non-human beings. We also outline how artificial intelligence, artificial evolution and network complexity may infuse this shared physicality with complex, playful and open-ended behaviour.

Conservation of Shadows is a site specific work for a gallery in the Seoul Innovation Center that was previously occupied by the Korea Center for Disease Control and Prevention for medicinal storage and animal experimentation. For this historically charged space we imagined unknown new beings growing fond of the wet texture of old wood, the fragrance of sunshine smeared between cracks, and the quietness of murmuring and whispering. To let them live, we extended senses to mix realities surrounded by softly ringing bells and the crunch of salt underfoot as their shadows pass by; and an alternate perspective through head-mounted display in which we become the shadows around which new beings play.

Image *Infranet: Gwangju.* Haru Ji & Graham Wakefield. Projections, Sound, Evolutionary NeuralNetworks, Geospatial Visualization.

Insuperposition is an ecosystem of vegetal and motile creatures subsisting on island-like topologies - in this case, five laser-cut topographies created by a combination of hand and algorithm, covered with a non-drying sand to allow reshaping. Visitors' shadows destroy and re-fertilize the land and movements distribute thousands of seeds through the spaces between islands. With the VR headset, visitors are shrunk to about an inch upon the islands, surrounded by foraging lifeforms, chirping their songs around the worlds. The change of spatial scale is echoed in a change of temporal scale on the large gallery wall, where a slow time-lapse scan around the islands unfolds.

Infranet: Gwangju is a generative artwork realized through a population of artificial life agents with neuro-evolution, communicating to form a liquid neural network that thrives upon open geospatial data of the infrastructure of Gwangju as its sustenance and canvas. It is also an aesthetic-cybernetic experiment in homeostasis as only a condition of heterostasis. Observing eyes surveil agents, however they appear to produce ever-changing patterns without need for extra regulation. Our city is an organism of infrastructure and transport. Born curious, we observe it, explore it and metabolize, taking on views contagiously, excitedly or by sway. Sometimes

our associations are too scattered, sometimes too close-knit. The living Gwangju we draw observes itself, spawning immune responses against overwhelming communicability, evolving variety over variety. We may become factory, farm or forest, as we see what unfolds.this case as visual entropy, that drives our response to the design of a neighbourhood or a city.

Haru Ji is a media artist exploring the subject of life in art through artificial life worldmaking, and co-creator of the research project Artificial Nature. She holds a Ph.D. in Media Arts and Technology from UCSB and is an Assistant Professor in Digital Painting Expanded Animation & Digital Futures programs at OCAD University in Toronto, Canada.

Graham Wakefield is an artist-researcher and software developer exploring the liveness of computation across immersive media. As an Assistant Professor in Computational Arts and the Canada Research Chair in Interactive Visualization, he directs the Alice Lab at York University. The lab develops transferable knowledge and creative coding technology as well as intensifying computationally literate art practice in the construction of responsive artificial worlds experienced through rapidly emerging mixed/hybrid reality technologies, including both Virtual Reality and Augmented Reality, as well as the Artificial Nature series.

Artificial Nature is a research-creation project beginning in 2008. Artificial Nature projects have been presented in art festivals, conferences and venues including SIGGRAPH, ISEA, EvoWorkshops, La Gaite Lyrique, ZKM, CAFA, MOXI, the AlloSphere and Seoul City Hall, and recognized in the 2015 VIDA Art & Artificial Life competition and the 2017 Kaleidoscope Virtual Reality showcase.

Image *The Conservation of Shadows* installation,
Seoul Museum of Art Chang-go, Seoul, Korea.
2017-10-17 - 2017-10-23. Haru Ji & Graham Wakefield.

Toward a Unified Behaviour Previsualization and Control System for Living Architecture Systems

Matt Gorbet
Gorbet Design, Inc., Toronto, Canada

Each new Living Architecture Systems Group installation offers potential for increasingly rich behaviour as the sensors, actuators and electronic control network become more numerous, integrated and powerful.

Simulation and extension of real-world physics phenomena, proprioception, emergent and self-regulating behaviours, and meaningful human interaction via networked sensors are just a few layers of the ecosystem of behaviours that one can anticipate this work exhibiting.

Already, exploration of machine learning and in-situ observational studies of participants has begun. Unfortunately, practicalities of the design workflow and process limit such exploration. The time and cycles required to iterate deeply and fully test behaviour paradigms have been short, as such activities can typically only occur after physical installation of the work.

To address this, we are currently evolving the software control system used in Living Architecture Systems Group testbeds to enable pre-visualization of behaviour during early stages of the design. The system will be able to generate a virtual representation of sensors and actuators present in an installation from data output by modeling software (that is already being used to pre-visualize the physical structures). The ecosystem of simulated elements is visualized in 3D, and their underlying software architecture mirrors the distributed firmware that runs on various microcontrollers within the installed testbed, enabling a direct transition from simulation to control once the physical installation is complete. Further, as a control system the software maintains the ability to represent the environment graphically, allowing for real-time visualization and 'hands-on' control of behaviours.

Benefits that we expect to realize with this new system include:

- Much greater flexibility and experimentation with behaviours during early stages of the design process, allowing behaviour design and choreography to inform the physical design and vice-versa before the work is installed
- A robust platform for adding and exploring various layers of behaviour such as physics simulation, interaction, and emergent behaviour
- A richer on-site control and debugging environment, including integration with physical controls such as sliders and knobs
- A solid path to previsualization of behaviour within augmented and virtual reality environments
- Enhanced STEAM outreach opportunities such as visualization of connections and communication within testbeds and hands-on manipulation of parameters
- Long-term cross-disciplinary impact on tools and workflow for designers of any material artifacts that integrate algorithmic behaviour

I will share some of the progress and challenges we face in developing the system, and discuss exciting new research potentials afforded by its deployment.

Matt Gorbet twists technology to create the unexpected. He co-founded Gorbet Design, Inc. to create unconventional objects and experiences in public spaces. These artwork and installation projects have been exhibited internationally and installed permanently in retail, hospitality and educational environments. Among the first graduates of the Tangible Media Group at the MIT Media Lab, Gorbett went on to become a member of research staff at Xerox PARC in the 1990s, where his multidisciplinary team pursued speculative design of new document genres. Gorbet has developed and taught Physical Computing and other design courses for the Canadian Film Centre and OCAD University, and co-founded a research lab at Ryerson University. He recently led a five-year project designing the infrastructure for the "Art+Technology" public art program at the San José International Airport. Gorbet's work with the LASG focuses on interaction and behaviour design, as well as technology integration and strategy. Gorbet holds several patents on novel interaction technologies.

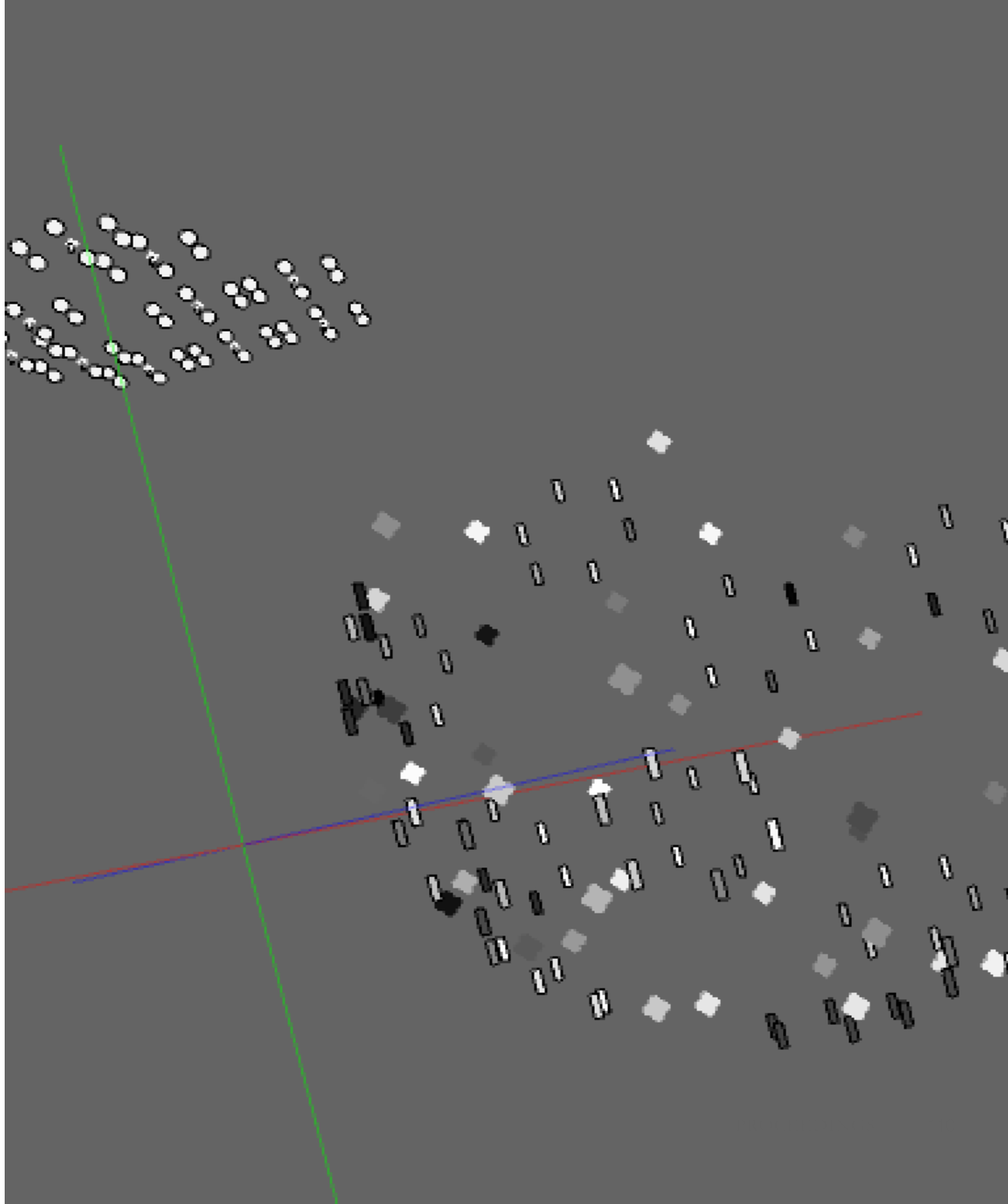

Image The new behaviour previsualization and control system is built using Processing. Its software architecture mirrors the distributed firmware that runs on various microcontrollers in physical space

Engaging People in Interactive Architectural Ecosystems

Tomasz Jaśkiewicz
TU Delft, Netherlands

Over the past decades, many architects have been exploring the possibilities of creating buildings that can grow, adapt and evolve. The recent developments in the areas such as the internet of things, artificial intelligence, smart materials or digital fabrication are helping to bring the technological promise of "living buildings" closer to everyday reality. At the same time, products such as "smart" speakers, thermostats, televisions, light bulbs and window blinds already proliferate in modern-day households, making buildings interactive from the inside-out. Yet, as technological limitations slowly move out of the way, the challenge remains how to make such interactive "architectural ecosystems" truly meaningful for people in their everyday lives.

The presented work is an account of a series of design and prototyping explorations involving an open office environment as a potent context. In the project, interconnected autonomous objects evolved throughout prototyping iterations to form symbiotic relationships with each other and with the people using them. In this process, teams of design and engineering students incrementally augmented typical office furniture objects such as chairs, tables or partition walls, by embedding them with interactive, data-exchanging and decision-making capabilities. Along the way, new functionalities emerged from synergies of prototyped connected office artifacts.

The process in which such shared functionalities emerged involved cyclical steps. First, designers observed the functioning of the prototypes in real world situations. Based on their observations, they redesigned the prototypes and adjusted ways in which the prototypes operated and communicated with each other. Subsequently the prototypes were again put to use

Image Iterative prototyping of connected interactive office products enables emergence of new functionalities, meanings and office practices.

in real-world situations and the cycle was repeated. Through such process, the evolution of created systems depended on designers as agents of their transformation. While tracing the development of created systems, we hypothesized a situation where designers could eventually step out of this process, with their role taken over by human and non-human agents partaking in the system. On the one hand, this perspective signifies the relevance of the discourse of the agency and autonomy of artificial, space-forming artifacts. On the other hand, it similarly raises the questions of the degree of agency and autonomy that human users of the architectural spaces should retain, and how to engage them more in the formation and trans-formation of "living building ecosystems."

Tomasz Jaśkiewicz is an Assistant Professor at the Industrial Design Engineering faculty at TU Delft in the Netherlands. He specializes in research through design involving iterative prototyping with interactive technology. In his projects, he investigates the challenges of user engagement in building transformation with a specific focus on sustainability in office buildings. Jaśkiewicz has a background in urban planning (TU Gdansk) and architectural design (TU Delft). He has practiced as an architect and architectural project manager, among others, in the experimental architecture firm ONL [Oosterhuis_Lénárd]. As part of his Ph.D. research, he investigated tools and methods for designing interactive and adaptable architectural environments. In his academic pursuits, Jaśkiewicz always aims to maintain the link to real world applications, which resulted in co-founding a start-up that develops software for design, simulation and deployment of distributed networks of interactive devices.

SC: Modular Software Suite for Composing Continuously-Evolving Responsive Environments

Brandon Mechtley, Julian Stein, Todd Ingalls,
Connor Rawls and Sha Xin Wei
Synthesis, Arizona State University, Phoenix, USA

SC is a modular suite of software designed to allow designers to compose the behavior of a responsive media environment evolving in concert with the contingent activity in a physical space. The rich media can be fairly arbitrary - projected video, spatialized audio, theatrical lighting - or more generally, fields of structured time-varying light and sound, as well as water, mist, animated objects etc. The behaviour of the responsive environment evolves according to prior design as well as contingent activity. A key condition is that everything happens in real-time, in concert with the activity of the inhabitants of the responsive environment. SC supports rich, thick experiences with poetic, symbolic and scientific effect.

Synthesis at Arizona State University provides a place for experimentally inventing and fusing fresh practices of understanding and enriching how the world works with fresh practices of making meaning. In 2014, Sha Xin Wei founded this atelier for fusion research with colleague research faculty Todd Ingalls and Brandon Mechtley. The group aims to extend and expand on fifteen years of prior work in the domains of responsive environments and live event, movement-based research creation at the Topological Media Lab, Concordia University, Montreal, and at Arts, Media + Engineering, Arizona State University, Tampe.

Image SERRA Vegetal Life installation, 2018
Oana Suteu Khintirian, Todd Ingalls, Sha Xin Wei + Synthesis @ ASU

Kinetic Architecture

Design-to-Robotic-Production and Operation

Henriette Bier
TU Delft, Netherlands

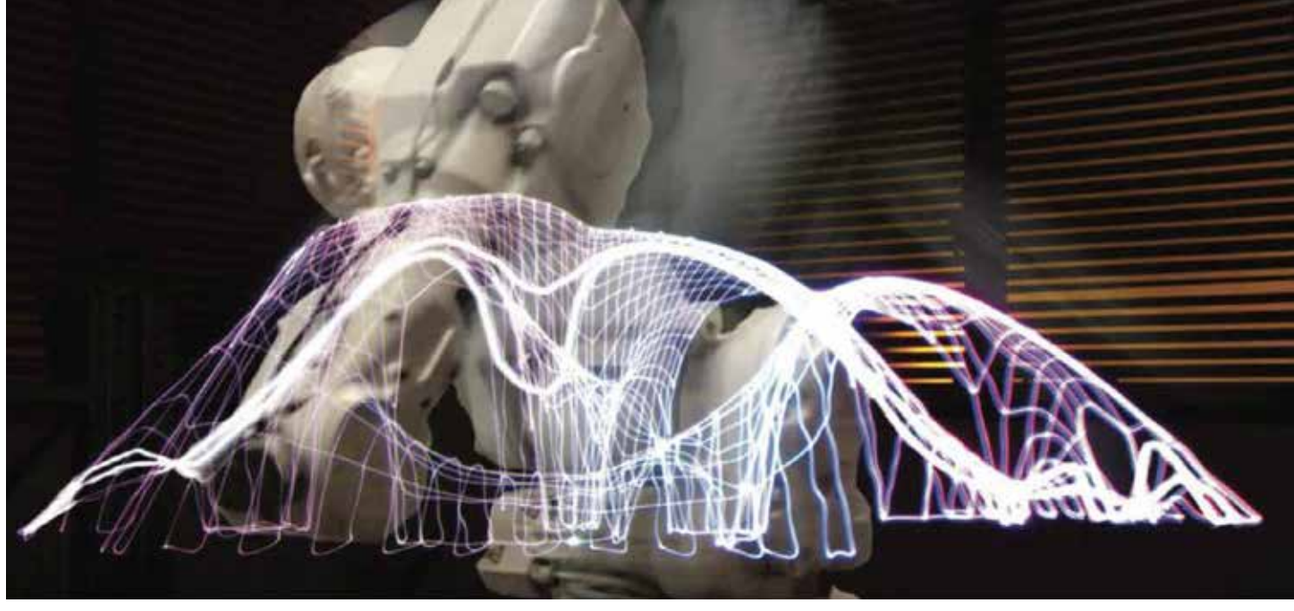

Image Scalable Porosity project implemented 2014-16 based on Design-to-Robotic-Production principles

The Robotic Building group at TU Delft focuses on the advancement of robotics in architecture. It was established in 2014 as part of Hyperbody and has been gradually integrated into Architectural Engineering since 2018. RB looks back to a successful history of four years: The group started with two members (Henriette Bier and Sina Mostafavi) and grew gradually to five members, with currently three additional researchers/tutors and one programmer (Arwin Hidding, Yu-Chou Chiang, and Vera Laszlo). Key moments in this period were the establishment of the first robotic lab in the Architecture and the Built Environment faculty hosting a KUKA robot, the establishment of the international collaborative framework Adaptive Environments involving partners from the EU and US, the successful two-year collaboration with the Dessau Institute of Architecture involving student exchange, the two 4TU-funded projects *Scalable Porosity* exhibited amongst others at Centre Pompidou and Variable Stiffness exhibited at Dutch Design Week, the publication of the first volume on *Robotic Building* in the Springer Book Series Adaptive Environments, and a TEDx Delft Salon presentation.

After graduating in Architecture from the University of Karlsruhe in Germany in 1998, Henriette Bier worked with Morphosis from 1999 to 2001 on international projects in the US and Europe. From 2002 to 2003, Bier taught computational design at various universities in the EU. Since 2004 she has been teaching and researching at Technical University Delft (TUD) with a focus on robotics in architecture. From 2005 to 2006, Bier initiated and coordinated workshops and lecture series on Digital Design and Fabrication with invited guests from MIT and ETHZ. In 2008, she finished her Ph.D. on System-embedded Intelligence in Architecture. From 2007 to 2010, Bier coordinated EU funded projects and led the 4TU-funded projects Scalable Porosity (2015-16) and Adaptive Stiffness (2017-18). In 2017, Bier was appointed professor at Dessau Institute of Architecture. Results of her research are internationally published in books, journals and conference proceedings. She is Editor-in-Chief of the Springer Series Adaptive Environments journal, and the Editor of Archidoct and Spool [CpA] journals.

Embodied Computation and Autonomous Architectural Robots

Axel Kilian
Massachusetts Institute of Technology, Cambridge, USA

Advances in autonomous control of object-scale robots are posing new human-machine interface challenges. A number of actuated architectural structures are discussed as architectural robots and how human occupation changes the object-centric robotic sensory paradigm. The Flexing Room installation was a room-sized actuated active-bending skeleton structure built as an inhabitable architectural robot. It used rudimentary social feedback by counting people to inform its behavior in the form of actuated poses of the room enclosure. To operate it, no geometric-based simulation was used; the only communication between computer and structure was sending values for the air pressure settings and gathering sensor feedback. The structure's physical state was resolved through the embodied computation of its interconnected active bending parts and the people counting sensor feedback used by the structure to influence its next action. The prototype was developed to provoke rethinking design using architectural autonomy to test open-ended behaviour guided by human feedback as a simplistic form of learning during the lifetime of the architectural structure.

Image Flexing Room prototype installed for the 2017 Seoul Biennale of Architecture and Urbanism

Axel Kilian is currently a Visiting Assistant Professor at the MIT Department of Architecture. He previously was an Assistant Professor at Princeton University's School of Architecture and at the Delft University of Technology and a Postdoctoral Associate at the MIT Department of Architecture. He holds a Ph.D. in Design and Computation and a Master of Science in Architectural Studies from the Department of Architecture MIT. He was a German-American Fulbright scholarship grantee and holds a professional degree in architecture from the University of the Arts Berlin. His most recent work in architectural robotics has been exhibited at the Istanbul Design Biennale and the Seoul Biennale of Architecture and Urbanism. His current research focus is on embodied computation, the continuation of computation in the physical realm.

Soft Kinetics

Vera Parlac
University of Calgary, Canada

The *Soft Kinetics* project is a part of a larger body of an ongoing design research that investigates the potential for kinetic and responsive architectural skin systems to influence the use of space and users' behaviour. The project explores the integration of custom-made soft robotic muscles into a component-based surface. The result of this project is a prototype of a light modular system capable of kinetic response to external stimuli such as occupancy or atmospheric conditions. The project focuses on kinetics of architectural surfaces and tectonics that integrate stasis and motion. It investigates the potential for a "programmable" architectural modular system that simultaneously addresses stability, dynamics and adaptability of a singular system.

In the Introduction of his 1970s book *Kinetic Architecture*, William Zuk, who was an engineer, architect and educator at the University of Virginia, speculates about changes in design approach necessary to envision architecture capable of kinematic movement. He suggests that new construction techniques, materials and technologies would have to be established. But even though kinetic architecture will require a more mechanistic and technological approach through the use of sensing technologies, new materials and embedded computation, it may also usher in a new kind of relationship between the human body and space. According to him, social relationships as well as personal sense of space and enclosure would be challenged. Associations between a dynamic body and dynamic space could provide a context where organization of human activities and experiences becomes more sensitive and responsive to changing needs, form and phenomena.

The project presented here looks for an alternative relationship between body and space. It uses soft pneumatic muscles as a form of actuation, seeks seamless transition between hard and soft elements of the modular system and tries to imagine new realities in which we can build responsive building skins that more intimately relate to the human body. In particular the project explores the capacity of *pneu* structures to produce a kinetic effect in architectural surfaces. Being delineated by an elastic membrane the *pneu* structure responds to the change of pressure by changing its mass. The change in pressure can cause considerable physical transformation of the structure. In this project the capacity of *pneus* to deform is used to produce kinetic effects in a larger construct and utilized to produce many different configurations. This research demonstrates the possibility to move parts of the aggregated structure by inflating and deflating integrated soft components (*pneus*). Degree of precision and control of movement depends on the volume and form of the soft component. The primary advantage of this mode of actuation is its lightness as well as a degree of control of movement. Another aspect is integration between the actuators and the system components. They are both modular and by fitting together they can be seamlessly integrated into one materials system.

Vera Parlac is a registered architect in Pennsylvania, USA and an Assistant Professor at the Faculty of Environmental Design at the University of Calgary. She received a Diploma Engineer in Architecture degree from the University of Belgrade and Master of Architecture degree from UCLA. Parlac is one of the founding co-directors of the Laboratory for Integrative Design (LID), a design research laboratory where design is engaged as a broadly integrative endeavor by fluidly navigating across different disciplinary territories. Parlac's current design and research is focused on responsive material systems and informed by contemporary models in biology, material science research and mechatronic systems. Prior to her appointment at the University of Calgary, she taught design and other subjects at several universities in North America, most recently at Temple University and in Hong Kong. Vera has worked at architectural firms in Philadelphia, Toronto, Boston, Miami and Los Angeles, including Carlos Zapata Design Studio and KieranTimberlake Associates.

Breathe

Manuel Kretzer
Anhalt University of Applied Sciences, Dessau, Germany

An ongoing collaboration with the German car manufacturer AUDI allows us to investigate scenarios of future mobility. The focus is especially on topics like autonomous driving and mobile car-sharing platforms, which will increase the demand for individual customization and adaptation of the interior.

The first project, which was realized with students from the Braunschweig University of Art in 2017, aimed at rethinking the classical car seat. The course started with an intense ideation phase, looking strongly into patterns and structures that can be found in nature, in order to diverge from traditional forms and shapes. We then explored how these inspirations could lead to a certain formal language and how they can be described using computer scripts and algorithms. Teaming up with Berlin-based company BigRep, a global producer of large-scale 3D printers, a prototype seat was eventually printed in 1:1. In addition to the 3D printed structure the seat contains 38 bespoke, active silicon cushions that are incorporated into its surface to dynamically adjust its visual and haptic properties, allowing the object to adapt to different situations or user demands.

Building upon the experience from this project a second collaboration took place in 2018, this time with a focus on the middle console. The students worked in groups, each developing their own specific scenario and design approach. Requirements, which each group had to address, were functional aspects (e.g. tray or cup holder options), formal expressions (using parametric/generative processes), technological production (applying digital fabrication techniques), sustainability (e.g. materiality, recycling etc.), interaction with and adaptation of the system and embedding the object into a larger narrative context. The project Alcyon proposes a bio-inspired center console produced by 3D printing, using a biodegradable filament made from algae. The structure is further planted with reindeer lichen - an organism consisting of algae and fungi, living in symbiosis without the need for human intervention. Lichens are used as bioindicators to demonstrate a habitable air quality while the algae provides oxygen through photosynthesis, impacting and improving the indoor climate.

The group Okura focused on the identification of the driver with the vehicle. While today a driver is an active part of a large system, the shift will be more towards passive scenarios where the user will become a mere passenger. To compensate for loss of control, alienation and a lack of security, the connection between man and machine must be improved. Okura represents an interactive surface, which informs, adapts and reacts. The dynamic scales of the surface move according to behavioral patterns, translating (e)motions into the interior and thus establishing trust into autonomous driving and artificial intelligence. Moreover, the surface can change its color from black to white in response to a change in temperature, which improves the interior climate.

Manuel Kretzer is a Professor of Material and Technology at the Dessau Department of Design, Anhalt University of Applied Sciences. His research investigates the design of dynamic and adaptive objects with a specific focus on new (smart) material performance as well as applying cutting edge digital design and fabrication tools. In 2012, he initiated Materiability, a free educational platform that attempts to connect architects, designers and artists and provides access to cutting edge new material developments and technologies. Dr. Kretzer is also a founding partner of responsive design studio based in Cologne. The core ambition of the studio is rooted in advanced design and manufacturing processes, and a commitment to exploring responsive, adaptive spatial interventions.

Breathe, 2017
Team: Moritz Boos, Maximilian Dauscha, Leon Ehmke, Lydia Jasmin Hempel, Dong-Kwon Lee, Tim Daniel Ingo Lüders, Vanessa Paladino, Benedikt Schaudinn, Sebastian Spiegler.
Braunschweig University of Art,

Past and Future Living Architecture

Exploring Organicism

Sarah Bonnemaison
Dalhousie University, Halifax, Canada

Do architects draw inspiration from living nature as they once did before the Industrial Revolution? I would say yes, absolutely, albeit differently. We have redefined 1960s optimistic wholism into a darker take on sustainable design with an emphasis on planetary interconnectedness. Riding the waves of the ecological crisis, the most beautiful designs of architects rekindle our spiritual senses - a reminder of the white veil stretching over Europe after the much-feared year 1000 AD.

As a historian and a designer, I see our interest in living nature as a fundamental impulse to draw inspiration from what we find beautiful and mysterious. During the 20th century, designers were drawn to the promise of mechanization and industrial production. Living nature, as a source of inspiration, was seen as old fashioned. The Arts and Crafts movement and Jugendstil kept Organicism afloat, as it was then called. organicism theory evolved in the organic in the work of Americans such as Sullivan, Root, Wright, and later on Khan and Ann Tyng, and Fuller. In Europe we have Gray, Mandelson, Aalto and Otto. In the developing world we have Hassan Fathy and others.

Today, I cannot help but notice the resurgence of organicist design principles, both in the aesthetics and in design methods of contemporary work. I propose to dive beneath biomimicry, biomorphism, green architecture and bio-design into the full richness of organicism. The intent is to draw Organicism principles from the past into meaningful constellations, including today's research into designs inspired by living nature. Just as stars can be linked together in different constellations, today I choose organicism as a way to link design projects together. LASG members are creators, people who share an ethics, a method of working

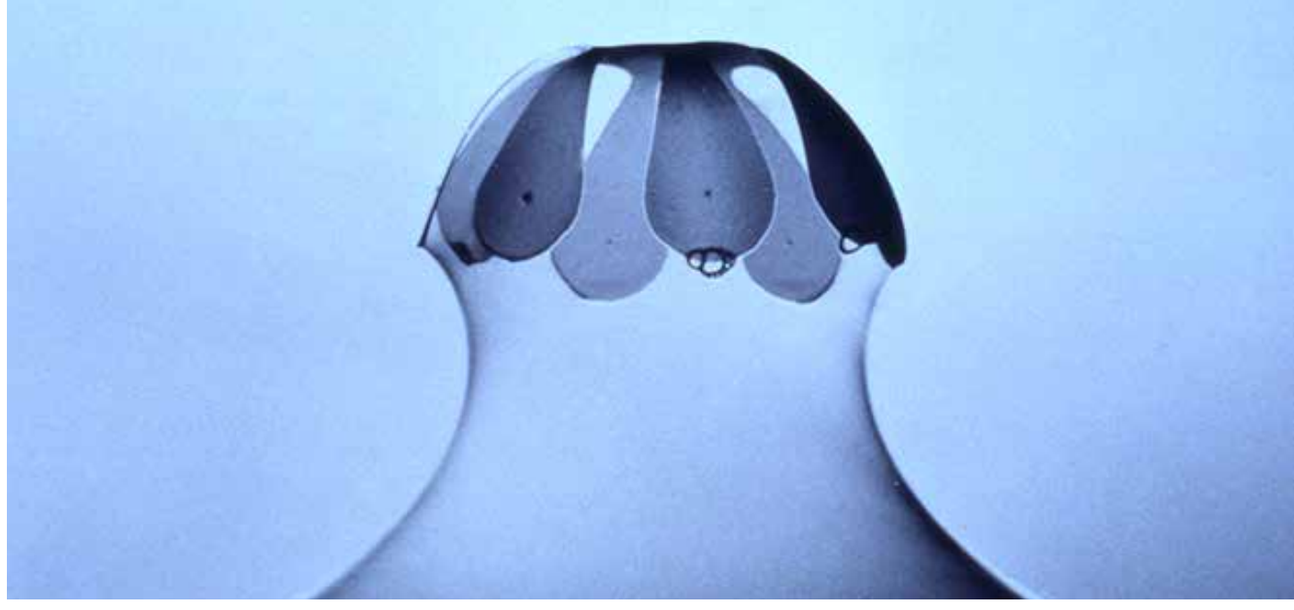

Image Soap film model for thumped tent by Frei Otto, 1970s

and even an aesthetic inspired by living organisms. LASG designers are the shining stars guiding me to create new constellations. Over the past year, I had the honour, and the privilege, of recording conversations about design and organicism with key members of LASG. These conversations provide a starting point to show how the work draws on organicism strategies and principles.

These principles include: the whole is larger than the sum of its parts; growth from within; human body as a metaphor of nature; Leon Battista Alberti's *concinnitas* (meaning: elegantly joined, skillfully put together and therefore beautiful and elegant). I will show how designers draw from organicism. For example, the body as a metaphor of nature (Alan Macy), growth from within (Carol Collet and Martyn Dade-Robertson), and *concinnitas* (Philip Beesley and Dana Kulić).

Sarah Bonnemaison is a Professor at Dalhousie University in the Faculty of Architecture and Planning. Her ongoing research interest is in architecture and its relation to nature, notably with the award-winning book Architecture and Nature: Creating the American Landscape (with Christine Macy) published by Routledge in 2003. She is currently writing about the resurgence of organicism in architectural theory and practice. Her design practice in tensile structures has now evolved into creating exhibitions such as the transformation of food in the modernist kitchen or the resurgence of organicism. The exhibition is conceived as a research tool that grows at each place it lands.

The Universal Human Attraction to Vitality

Colin Ellard
University of Waterloo, Canada

What is life? By this I don't mean boilerplate definitions that specify that living things must self-replicate and possess metabolism. Rather, I'm talking about perceptions of life. When do we recognize that something is alive, what attracts us to this vitality and why does it do so? I suggest a kind of affective variation of the Turing Test which says that something is alive when we feel that it is alive. Though this definition lacks formality, it honours the universal human attraction to vitality and helps to explain why people will line up for hours to commune with one of Philip Beesley's sculptural creations. In the work that is most directly related to the objectives of the LASG, my student Adam Francey has been trying to understand the fundaments of our perception of vitality using mock-ups of geometric shapes in virtual reality. That's certainly one viable approach to the problem that has found proof beginning with the work of Fritz Heider and Marianne Simmel (1944), when they showed that simple animations of shapes were seen as being imbued with complex emotions and motivations.[1] But in odd ways, much of my work in what I used to think were quite different domains has become enmeshed in a more general notion of a human gravitational attraction to vitality.

In work on the robust finding that we are attracted to visual scenes that contain nature, Deltcho Valtchanov and I discovered that there are deep mathematical properties of visual scenes that, when tweaked in just the right way, generate positive emotional responses from humans. [2] These properties, having to do with the spatial composition of the image, suggest first of all that our brains respond positively to vitality and secondly that whether or not we see this property in an object or scene depends less on the semantics of the scene and more on its structure. In other words, it doesn't really matter whether the scene is one of nature so much as whether it resembles a vital scene structurally.

In other seemingly unrelated work, my students and I have studied psychological responses to streetscapes, and we have discovered that here, too, there is a deeply positive response to the appearance of vitality, quantified in this case as visual entropy, that drives our emotional response to the design of a neighbourhood or a city.

As a neuroscientist, I am tantalized by the deep connections between the detection of animism in creative interactive art, the emotional response to a perceptual calculus that signals the existence of life, and engaging urban designs that elicit positive affect by offering enough information to satisfy the cravings of our minds. We see the emotional appeal of life engendered strongly in the installations that can be said to form the centrepiece of our work with LASG, but we see echoes of this same attraction to living structures in every domain from our engagement with a natural landscape to the forces that act to produce commodious and appealing urban environments.

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1 Heider F & Simmel M (1944). "An experimental study of apparent behavior." The American Journal of Psychology, 57(2), 243-259.

2 Valtchanov D & Ellard C (2015). "Cognitive and affective responses to natural scenes: Effects of low-level visual properties on preference, cognitive load, and eye movements." Journal of Environmental Psychology, 43, 184-195.

Colin Ellard is a Professor of Cognitive Neuroscience at the University of Waterloo and the Director of the Urban Realities Laboratory, which engages with issues at the intersection of psychology, neuroscience, architecture and urban design. Ellard's work has been published in peer-reviewed journals in North America, Europe and Asia for the past 30 years, where he has made contributions to perceptual neuroscience, architectural psychology and environmental design. An important part of Ellard's practice involves collaboration and consultation with artists, architects and urban planners for both theoretical and practical purposes. He is a member of the advisory council of the Academy of Neuroscience for Architecture and a frequent keynote speaker at science and design conferences worldwide. He has published books aimed at a general audience, the most recent being Places of the Heart (Bellevue Literary Press, 2015). Ellard is the leader of the LASG's Human Interaction stream.

Worldmaking as Techné

Participatory Art, Music and Architecture

Mark-David Hosale
York University, Toronto, Canada

Worldmaking as Techné: Participatory Art, Music, and Architecture outlines a practice that challenges the World and how it could be through a kind of future-making, and/or other world making, by creating alternate realities as artworks that are simultaneously ontological propositions. In simplified terms the concept of *techné* is concerned with the art and craft of making. In particular a kind of practice that embodies the enactment of theoretical approach that helps determine the significance of the work, how it was made, and why. By positioning worldmaking as a kind of *techné*, we seek to create a discourse of art-making as an enframing of the world that results in the expression of ontological propositions through the creation of art worlds.

Image Empty Space photo by Laura Beloff, 2009.

Mark-David Hosale is a computational artist and composer. His work explores the boundaries between the virtual and the physical world. His practice varies from performance (music and theatre) to public and gallery-based art. The connecting tissue in his work is an interest in knowing. Hosale is an Associate Professor in Computational Arts at York University, Toronto. He has lectured and taught internationally at institutions in Denmark, The Netherlands, Norway, Canada and the United States. His solo and collaborative work has been exhibited internationally at the SIGGRAPH Art Gallery (2005), International Symposium on Electronic Art (ISEA 2006), BlikOpener Festival, Delft, The Netherlands (2010), the Dutch Electronic Art Festival (DEAF 2012), Biennale of Sydney (2012), Toronto's Nuit Blanche (2012), Art Souterrain, Montréal (2013), and a collateral event at the Venice Biennale (2015), among others. He is co-editor of the anthology Worldmaking as Techné: Participatory Art, Music, and Architecture (Riverside Architectural Press, 2018).

Form from Process

Jekabs Zvilna and Integrative Form-Languages

Val Rynnimeri
University of Waterloo, Cambridge, Canada

An outline of new research from the archive of Waterloo Architecture professor Jakebs Zvlina shows his pioneering research during the1960s and '70s. Zvilina's conceptions anticipated development in contemporary complexity studies and form generation. His extraordinary output of work, done in non-digital media like photograms, drawings and models, can be positioned within contemporary and historical architectural theories of Organicism, albeit one derived from process driven geometric studies. The research will explore conceptions of geometry as an organic form-language by developing digital models, drawings and collating a base of texts that explore the body of Zvilna's inventive work, and which can be framed by a broader background of contemporary 'organicism' and interdisciplinary complex-systems theory. Culmination of the research will set up the framework for a small exhibition to follow, associated with the Living Architecture Systems Group, and documented within a folio to be published by the LASG with Riverside Architectural Press. The research will include collaboration with other professors emeriti from Waterloo. Digital modeling will be supported by parametric modeling advice provided by expert LASG researcher Timothy Boll. There will hopefully be the opportunity to develop advanced conceptions of Zvilna's three-dimensional geometry research in digital form.

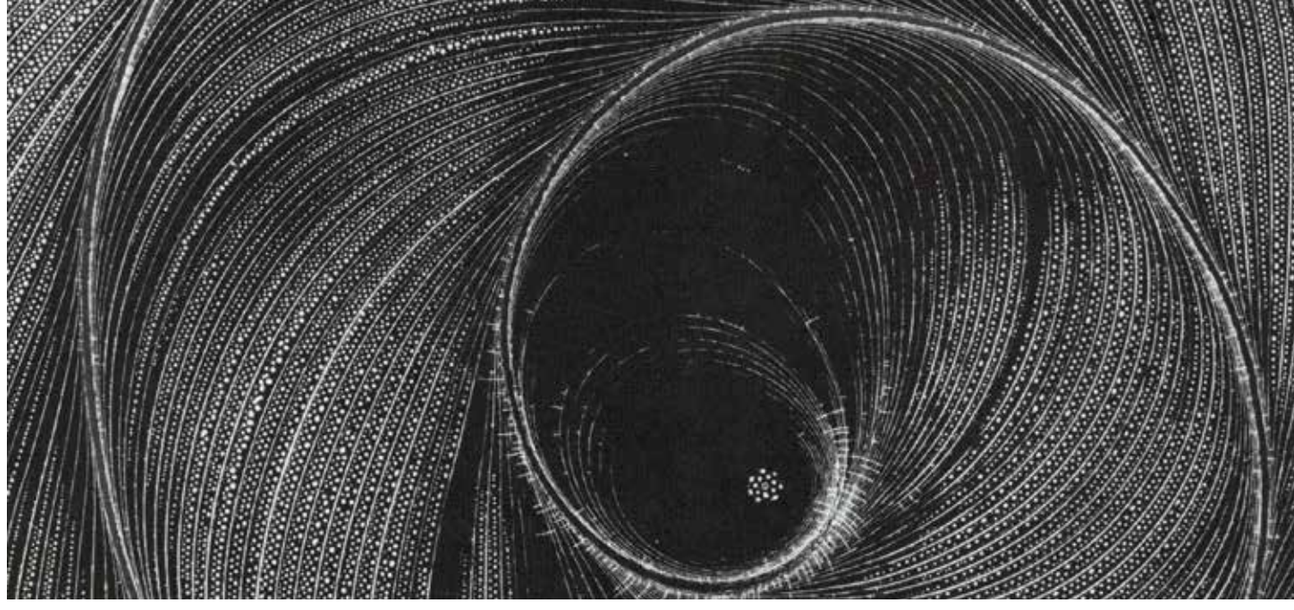

Image Motion by Jekabs Zvilna. From http://archinect.com

Val Rynnimeri is an Associate Professor at Waterloo Architecture, Cambridge, ON. His work focuses on landscape and urban design, the incremental mechanics of land development in the metropolitan periphery, and the ecosystem based design of urban parks and green infrastructure. He has worked for several offices in Toronto, New York and Waterloo. While at Toronto's MBTW Group in the 1990s, Val put forward ideas of suburban intensification and the green infrastructure that today have become a common in GTA planning. Presently he is working on the completion of a book on Toronto's Don Mills. Val has a B.E.S Waterloo, B. Arch. Waterloo and an M.A. Guelph (History).

Autodesk Technology Centers and Residency Program

Ellen Hlozan and Matthew Spremulli
Autodesk Technology Centre, Toronto, Canada

Image Generative Design Technology explored at Autodesk Technology Centers

Autodesk Technology Centers are where the future of making takes shape. With locations around the world, we invite industry, academic and entrepreneurial communities to reimagine what it means to design and make, and to create a shared vision of the future that will enable people to do more and make better things with less negative impact.

Autodesk provides the facilities, technology and equipment, training, and expertise for these communities to explore ideas that will shape the future. Each location—San Francisco, Boston, Toronto and Birmingham, UK—explores different aspects of the future of making, from construction to advanced manufacturing to artificial intelligence and generative design. But all the spaces are designed to foster open innovation and advance the industries that help imagine, design and make the world around us.

Autodesk Technology Centre - Toronto

The Autodesk Technology Centre in Toronto explores emerging technologies that will help us design and make in ways previously unimaginable. The centre is home to advanced research in areas such as machine learning, generative design and artificial intelligence, and is where that research is applied to create solutions that help people do more and make better things, with less negative impact on the world.

Located in Toronto's MaRS Discovery District, one of the world's largest urban innovation hubs, the centre is generatively designed to facilitate a collaborative community. It offers dedicated workspace, along with access to prototyping and visualization tools, where Autodesk customers, industry experts, and academic and government leaders can come together to explore the future of making.

Ellen Hlozan is the Community Engagement Program Coordinator with the Autodesk Technology Centre in Toronto, where she is focused on developing innovative programming with residents, researchers and broader Toronto technology communities. Hlozan is passionate about inspiring critical dialogue on tech, art and design through exhibitions and engagements. She has worked on a number of high-profile events in the city, including HotDocs DocX VR Installation.

Matthew Spremulli is an Innovation Project Manager with the Autodesk Technology Centre in Toronto, where he is focused on bringing in academics, entrepreneurs and industry groups to explore the "future of making" through the residency program. Spremulli is passionate about democratizing technology as well as public engagement/exhibition projects. Spremulli also teaches New Media and Technology for the University of Toronto's Landscape Architecture program.

Sketches of Tectonic Culture

Michael Stacey
The Bartlett School of Architecture, London, UK

Construction, technology and architecture will be analysed in the form of sketches of tectonic culture, via four case studies from the recent past: The dome of Santa Maria del Fiore, Glenfinnan Viaduct, All Saints' (Brockhampton-by-Ross) and Fallingwater.

The dome of Santa Maria del Fiore, Duomo di Firenze was designed Filippo Brunelleschi. The cathedral was founded in 1296 and the form of the dome was set in 1367. In essence, it is a Gothic dome although it has become an icon of the Renaissance. The dome was constructed between 1418-1436. The use of one-to-one drawings by Filippo Brunelleschi in the design of the dome of Santa Maria del Fiore, Duomo di Firenze as a means of controlling the doubly curved shells of the dome will be discussed. Glenfinnan Viaduct, Scotland, 1898, engineers Simpson & Wilson, contractor Sir Robert McAlpine, was the first mass concrete structure in the United Kingdom. All Saints', Brockhampton-by-Ross, Herefordshire, 1902, architect William Lethaby, is an Arts and Crafts Church with an in-situ concrete roof over the nave. Fallingwater or Kaufmann Residence, Pennsylvania, USA, architect Frank Lloyd Wright, 1935, has extensive in-situ concrete cantilevers. Three are new cases studies in the second edition of Concrete; a studio design guide

Image A section through the dome of Santa Maria del Fiore, Duomo di Firenze, drawn by Filippo Brunelleschi

Image Glenfinnan Viaduct, Scotland, 1898, engineers Simpson & Wilson, contractor Sir Robert McAlpine

Image Fallingwater or Kaufmann Residence, Pennsylvania, USA, architect Frank Lloyd Wright, 1935

prepared by the author for RIBA Publishing (2019). Glenfinnan Viaduct and Fallingwater will also be analysed as example of geomorphology.

This sketch of tectonic culture will consider the roles of tradition and change, of invention, new technologies and the importance of design. New technology may be a source of inspiration for new architecture; however, the skill of architects and engineers in deploying construction technology is considered to be more important than the technology itself. The contemporary tendency just to collage the construction of buildings will also be reviewed. Can construction professions collectively reclaim contemporary architecture from the 'biscuits boys and biscuit girls'?

Michael Stacey's professional life combines practice, teaching, research and writing. His portfolio of projects and products has been recognised by national and international awards, including twice winning the Shapemakers Award for the Innovative Use of Aluminium, a Bureau International du Beton Award, RIBA Awards and an Award from the Campaign for the Preservation of Rural England. In 2013 The Renault Centre, 1982, which he worked on at Foster Associates, was listed Grade II*. He has taught architecture at Liverpool University, Penn Design, London Metropolitan University, the Architectural Association, The University of Nottingham and currently on M.Eng Engineering & Architectural Design at the Bartlett, University College London.

First published in the Architects Journal in 1985, he is the author of a wide range of publications and books including: Component Design, 2001, Digital Fabrication, 2004, Concrete: a studio design guide, 2011, second edition 2019, Prototyping Architecture, 2013, Aluminium and Durability, 2014, second edition 2015, Aluminium Recyclability and Recycling, 2015, Aluminium: Flexible and Light, 2016, and Aluminium Sympathetic and Powerful, 2017. RIBA Publishing has commissioned a series of Studio Design Guides and next will be Aluminium: a Studio Design Guide, 2019. Current research programmes include: Towards Sustainable Cities: quantifying the in-use benefits of Aluminium in Architecture and the Built Environment with Kieran Timberlake for the International Aluminium Institute and Living Architecture Systems Group with Philip Beesley Architect, funded by SSHRC, Canada.

The Future of the World Depends on Us Being Better Collaborators

JD Talasek
National Academy of Sciences, Washington, D.C., USA

It seems that nothing of significance in the 21st Century happens unless people collaborate. From imagining a new inspirational performance piece to designing better health care, our depth of knowledge and advancing technologies requires that we be able to work effectively with - perhaps be inspired by - others who have different skills but a shared passion for a desired outcome. What is the role of artist and designer in imagining and creating the world in which we want to live?

For fifteen years, the National Academies Keck Futures Initiative (NAKFI) conducted experiments in cross-disciplinary interactions. In 2003 when the program began, many believed that the discoveries that would lead to solving the world's most pressing problems would be based on interdisciplinary and cross-professional research. The original manifestation of the program included participants primarily from the STEM disciplines. But in 2015, artists and designers were invited into the mix, yielding some very interesting results. By engaging with a broader range of disciplines, participants experienced the importance of engaging through an aesthetic experience, stimulating creativity and innovations. I will share a number of examples from the last three years of the NAKFI experience that resulted from art and science collaborations.

Image Crude Life Portable Museum: A Citizen Art and Science Investigation of Gulf of Mexico Biodiversity after the Deepwater Horizon Oil Spill. Brandon Ballengée (Louisiana State University); Prosanta Chakrabarty (Louisiana State University); Sean Owen Miller (University of Florida); and Rachel Mayeri (Harvey Mudd College)

JD Talasek is the Director of Cultural Programs of the National Academy of Sciences. He is the creator and moderator for a monthly salon called DASER (DC Art Science Evening Rendezvous) held at the NAS, part of the LASER network.

Talasek is currently on the faculty at Johns Hopkins University in the Museum Studies Master's Program. Additionally, he serves on the Contemporary Art and Science Committee (CASC) at the Smithsonian's National Museum of Natural History. He is the art advisor for Issues in Science and Technology Magazine and is currently the Art and Design Advisor for the National Academies Keck Futures Initiative based in Irvine, CA. Talasek is a board member of Leonardo/International Society for Art Science and Technology and chairs the LASER committee that coordinates more than thirty art/sci salons around the world.

Talasek was the creator and organizer of two international online symposia (and co-editor of the subsequent published transcripts: Visual Culture + Bioscience (2009, DAP) and Visual Culture + Evolution (2010, DAP)).

Living Architecture
Systems Group 2019

Living Architecture Systems Group 2019

The Living Architecture Systems Group is an interdisciplinary partnership of academics, artists, designers and industry partners dedicated to researching and developing next-generation architectural environments. Environments produced by this group are now showing qualities that come strikingly close to life, transforming the built world. These experimental works can move, respond, explore, learn and adapt. The LASG disseminates its work through exhibitions, publications and events.

The LASG is generously supported by Social Sciences and Humanities Research Council of Canada (SSHRC), University of Waterloo, Canada Council for the Arts, Ontario Arts Council, Toronto Arts Council, National Academies Keck Futures Initiative, OCAD University, MITACS, Voltera, Formlabs, and the Consulate General of the Kingdom of The Netherlands.

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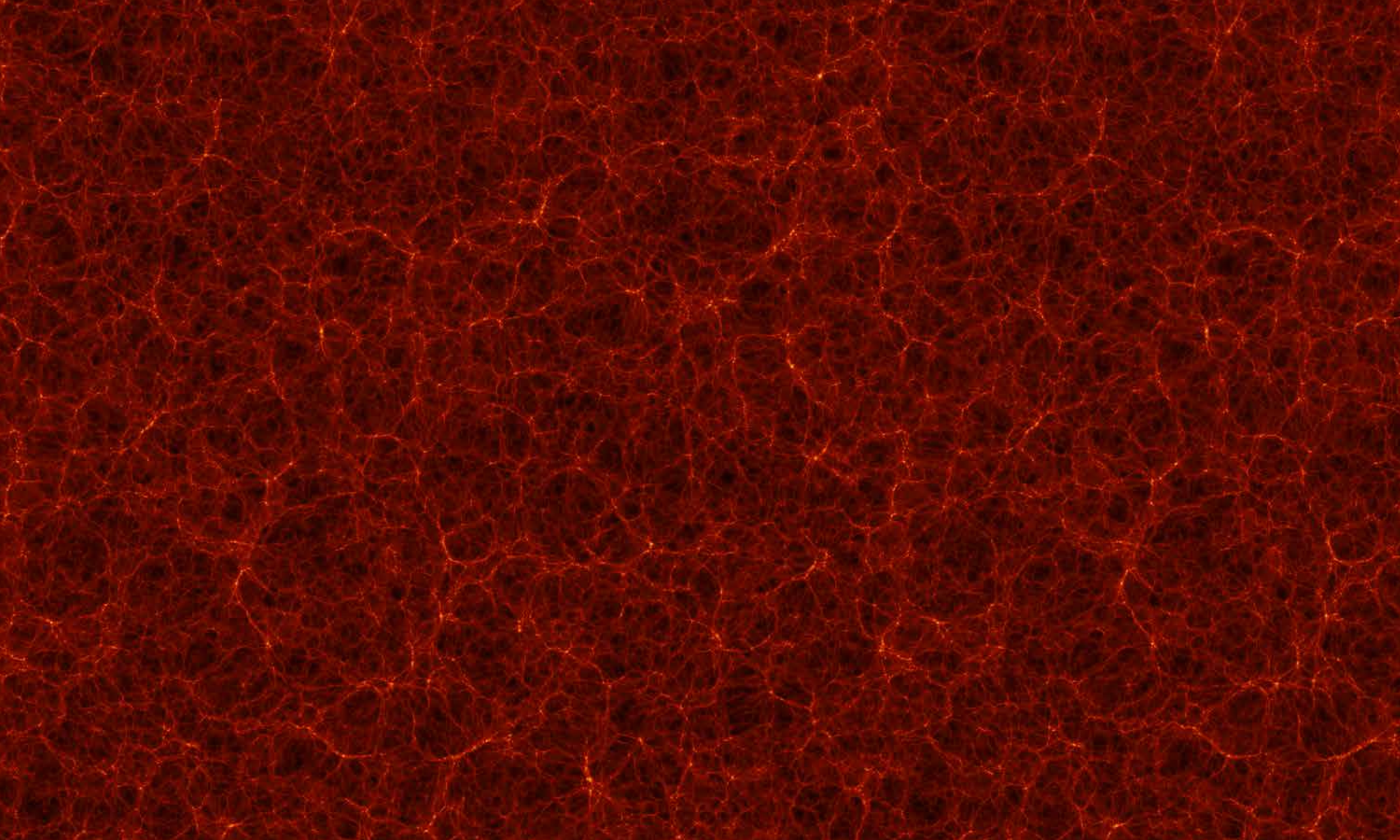

LIVING ARCHITECTURE SYSTEMS GROUP

Symposium 2019 Proceedings

On March 1-3, 2019, the Living Architecture Systems Group Symposium gathered together a research network of architects, artists, engineers, scientists and artists exploring responsive and adaptive qualities in contemporary architecture. The *Symposium 2019 Proceedings* is a compendium of abstracts of papers presented at the Symposium that investigate boundaries between living forms, synthetic materiality, interactive technologies and behaviour. Presentations by 44 contributors cover topics including biomimicry, expanded definitions of living systems, artificial intelligence, interactive systems of immersive sound, motion and lighting, sentient cities and intelligent infrastructures, organicism and ecology. Creative expressions and scientific analyses are included at scales ranging from intimate couture to regional design.

Edited by Philip Beesley & Sascha Hastings

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