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David Gerber · Evangelos Pantazis ·
Biayna Bogosian · Alicia Nahmad ·
Constantinos Miltiadis (Eds.)

Computer-Aided Architectural Design

Design Imperatives: The Future is Now

19th International Conference, CAAD Futures 2021
Los Angeles, CA, USA, July 16–18, 2021
Selected Papers

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Editors
David Gerber
University of Southern California
Los Angeles, CA, USA

Biayna Bogosian
Florida International University
Miami, FL, USA

Constantinos Miltiadis
Aalto University
Espoo, Finland

Evangelos Pantazis
University of Southern California
Los Angeles, CA, USA

Alicia Nahmad
University of Calgary
Calgary, Canada

Preface

The CAAD Futures 2021 Conference, with the theme "Design Imperatives: The Future is Now", was hosted by the University of Southern California (USC) Viterbi School of Engineering and took place virtually during July 16–18, 2021. The conference call, formulated during the beginning of the COVID-19 global pandemic, focused on highlighting how computational design research could address the immediate and imminent issues influencing the built environment. This call attracted 97 paper submissions that went through a rigorous double-blind peer-review process resulting in 33 accepted and presented papers through the conference, which attracted 90 registered attendees. The selected papers were presented within seven tracks and are included in the present publication.

In addition to the paper presentations, 28 guest speakers and co-panelists contributed to 13 sessions on a wide range of topics, which complemented and elaborated on the conference theme. Furthermore, 10 selected workshops were conducted involving 26 tutors and 88 participants. The following editorial offers more information and contextualizes the conference.

2021 Conference History and Organization

CAAD Futures 2021 was initiated by David Gerber (of USC) on behalf of the CAAD Futures Foundation, who established the general theme "Design Imperatives: The Future is Now." By mid-2020, the organizing committee was assembled to include Biayna Bogosian (of USC and later Florida International University), Evan Pantazis (of USC and IBI Group), Alicia Nahmad (of the Architectural Association and later the University of Calgary), and Constantinos Miltiadis (of Aalto University).

The team commenced conference organization during the height of the COVID-19 pandemic, carrying out weekly remote meetings from July 2020 until July 2021, when the conference took place. Undoubtedly, the ongoing pandemic was an immense challenge for the conference and its organization, which necessitated the team to plan for the contingencies of the circumstances.

The first uncertainty was whether the conference could be hosted in person at USC or if we had to resort to a remote, teleconferencing format. Our initial planning suggested a hybrid format, in which the participants could join remotely or in-person. However, by March 2021, following health and safety directives, it was decided that the conference had to be conducted in a remote virtual format.

Another uncertainty was a concern regarding the impact of the pandemic on research. The regulations imposed on universities across the globe for restricting the spread of the virus had significant repercussions on how the research was carried out. On the one hand, access to labs, infrastructure, and physical spaces for conducting research and experiments was limited. On the other hand, day-to-day activities that inform research, such as teaching, interpersonal communication, and peer-to-peer feedback, also had to adapt to the challenging remote conditions.

In light of the above, the commitment of the organizing committee was to actualize the conference despite all the uncertainties and attempt to organize a significant event for the research community. The drive for the conference organization was based on the fact that the CAAD Futures conferences have been essential discussion hubs for the computational design community and the pandemic, more than anything, highlighted the importance of community building. Also, the distributed nature of the global pandemic has brought to the forefront several previously discussed matters, such as the notion of virtual space and the digitization of our profession. Thus, it was an opportunity to look at these critically and in the light of the conference theme.

On the Open Call and CAAD Futures Conference

The open call was drafted in August 2020 and was developed upon the founding mission of CAAD Futures, established in 1985. The CAAD Futures organization was formed to promote "the advancement of Computer Aided Architectural Design in the service of those concerned with the quality of the built environment," to play an active role in promoting research interactions and collaborations, and to facilitate the dissemination of research.

Our principal consideration, 35 years later, was how to reframe promoting the advancement of CAAD when computation and related tools permeate all facets of architecture—practice, education, and research—while computation itself has diversified immensely to account for sub-genres, disciplines, and methodologies. Our intention with the call (shared below) was to be inclusive and affirmative to all facets related to computation, to account for the phenomenon at large, and for the conference to serve as a convergence for the different contemporary and relevant streams of research, and their respective researchers.

The suggested thematic areas included relatively recent strands such as machine learning and already established ones such as fabrication and design automation, as well as inter-and cross-disciplinary domains topical to computational practices like shared economies, matters of ethics, policy, equity, and sustainability. The call also provisioned for matters of research methodology, education, and literacy, in addition to open-source tools and initiatives. Finally, diametrically opposed to the conference theme, the track 'Past Futures' was intended to account for computation as an evolving historical phenomenon, its heritage, and critique.

The call was shared in September 2020 and remained open until March 2021, collecting 97 full papers submitted for review. Next to the call for papers, a call for workshops (including technical tutorials, seminars, and hackathons), collected 26 proposals. Of the 10 workshops selected, nine were conducted remotely with one conducted in person in Los Angeles, USA.

Lastly, the organizing committee planned a series of panel discussions with a number of invited field experts from both academia and the industry. These took place between conference paper presentations, reflecting and elaborating on different aspects of the open call.

We provide the open call for submissions and brief descriptions of the discussion panel topics in the following subsections.

Keynotes and Panel Discussions

Day 1: July 16, 2021

The conference began with an opening keynote presentation by Chris Luebkeman, who gave his interpretation of the conference theme discussing contemporary necessities such as the democratization of tools, the popularization of techniques, and the ubiquity of data, proposing regeneration and circularity principles additional to sustainability.

The first panel discussion of the day, titled "Digital Regionalism & Other Computational Futures", featured Theodora Vardouli, Rodrigo Orchigame, and Daniel Cardoso Llach. Vardouli opened the panel by discussing the archeology of graph theory in architecture and its impact on topology and geometry. Orchigame followed with a presentation of past paradigms in computation and logics developed in Brazil, Cuba, and India, elaborating on inconsistency, uncertainty, and partiality, respectively. Cardoso Llach discussed the pitfalls in the history of computation, stating that "after 50 years of computer-aided and computational design, we are still not drawing things together" and proposing a more sincere and transparent view on design media.

The second panel discussion of the day, titled "AI, the Built Environment & Human Wellbeing", with participants Chanuki Illushka Seresinhe, John Law, and Nono Martinez Alonso discussed how different deep learning techniques could be used to understand how we perceive our cities and how they affect us. Illushka Seresinhe argued that machine learning could help us to consider the built environment in terms of human subjectivities and social wellbeing. She further discussed the use of big datasets and deep learning to understand how the aesthetics of the environment influence human wellbeing. Law presented AI techniques for quantifying the perception of urban typologies by their users and their effects on design and human settlements, questioning how we might design future cities conducive to our wellbeing. Martinez Alonso discussed different techniques to engage with machine learning processes from a design perspective.

The third panel discussion of the day, titled "Computation and the State of Practice", consisted of Jason King, Pablo Zamorano, Silvan Oesterle, and Maryanne Wachter. They attempted to draw a picture of the contemporary situation in computational design teams in larger firms and smaller design practices. Following brief presentations, the discussion addressed opportunities within large organizations to apply computational techniques and methods and how these can leverage small practices. It also highlighted transparency in developing processes, workflows, and longitudinal integration. It advocated for the long-term development of tools that can be used across scales and projects—an alternative to frequent practices of developing ad hoc and project-based solutions.

The closing keynote of the day, titled "An Intro to Native IFC and Open Source AEC", was presented by Dion Moult, initiator of Blender BIM and contributor to open-source projects such as the IfcOpenShell and Ladybug tools. Moult discussed the imperative and inevitability of developing open standards, workflows, and open-source tools with and within the design community, emphasizing their social and political implications. His

presentation concluded with a demonstration of Open IFC in practice and an invitation to participate in OS Arch projects.

Day 2: July 17, 2021

The second day started with a keynote by Cristiano Ceccato, who presented the design and construction process of several large-scale airport terminals built recently by Zaha Hadid Architects. His talk discussed the importance of advanced design tools in their practice and drew parallels between aircraft manufacturing and modern-day construction in terms of complexity. He concluded the talk by addressing how new technologies can help overcome challenges and outlined several parameters for shaping what he called more "hopeful futures."

The first panel discussion of the day, titled "Virtual Worlds", included Konstantinos Dimopoulos, Jose Sanchez, and Kate Parsons. Dimopoulos elaborated on a definition of video game urbanism and its contribution to worldbuilding stemming from his practice. Next, Sanchez discussed his upcoming video game 'Common'hood' intended to promote practices of commoning and social engagement through collaboration in the digital domain. Lastly, Parsons presented her methodology for designing immersive environments and her interest in NFT art production and dissemination. The discussion revolved around how social engagement in the virtual domain contributes to the 'real' physical world.

The second panel discussion of the day, titled "Digital Literacy", was a discussion with Vera Bühlmann and Ludger Hovestadt hosted by Constantinos Miltiadis and Evan Pantazis on 'claiming architectonic questions again.' It started with a brief introduction of the Chair for CAAD (now Digital Architectonics) and its legacy and continued with examples from the guests' current pedagogical project. Hovestadt emphasized that technology today is too easy. Contemporary architectonics requires rhetoric and philology to engender 'digital renaissance'. Bühlmann highlighted the need to construct instruments to find stability in the contemporary world, embracing as ethics the art of abstract gnomonics.

David Benjamin conducted the closing keynote of the day. He presented his research methodology, which unifies his teachings at Columbia GSAPP and his practice The Living, to rethink the concept of innovative and sustainable design processing. The work presented touched upon a lot of topics which included synthetic biology, sustainable material science, AI-driven computational design workflows, and environmental sensing. Most importantly, Benjamin discussed how we should be thinking about designing for change over time and how computational methods and data can help manage complexity by actively correlating visible and invisible parameters.

Day 3: July 18, 2021

The third day started with a keynote by Martha Tsigkari who introduced recent technologies and tools in the areas of form-finding, machine learning, AR/VR, robotics, optimization, and analysis used by the Applied Research and Development (ARD) group within Foster + Partners. She outlined how such tools extend the designers' intuition and enhance the performance-driven design and remote design collaboration. Tsingari

also discussed the importance of data for the design process and applications that enable designers' real-time feedback. She concluded by presenting a vision of technology and design tools as collaborators and enhancers of human intuition and tools that allow problem-solving.

The first panel discussion of the day, titled "Designing Materials and Interactions", consisted of Behnaz Farahi, Felicia Davis, and Maddy Maxey. Through her work and the critical lens of feminism, emotion, bodily perception, and social interaction, Farahi focused on the relationship between the human body and its embodied space. Davis presented her work on computational textiles and how responsiveness and aesthetics could embed socio-spatial and political dynamics. Finally, Maxey presented research on wearables and e-textile prototypes that combine interactive design with haptics to communicate complex human and machine relationships.

The "Data and Policy" panel included Wendy W. Fok, Matthias Standfest, Maider Llaguno-Munixta, and Yannis Orfanos. Starting the discussion, Standfest presented his research on architectural and urban performance modeling and the role of machine learning in advancing the field. Next, Llaguno-Munixta presented her research on studying air pollution and the importance of data resolution in developing novel design practices that improve environmental health. Orfanos followed up by presenting his research on using data and information visualization to expand the way we think about spatial design and analysis in various scales. Finally, Fok highlighted that in conversations about data and design, it is essential to understand the role of digital property, authorship, and ownership.

The conference's closing keynote was given by Marcos Novak, who elaborated on the conference call and reflected on the past 30 years of computation in architecture and urban design. His presentation, spanning from classical to contemporary times, traced characteristics of each era's avant-garde, speculating on which those could be for the 21st century. He concluded by outlining *THEMAS* (Technologies, Humanities, Engineering, Mathematics, Arts and Sciences), a holistic and integrative model for research practice and pedagogy.

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September 2021

David Gerber
Alicia Nahmad
Biayna Bogosian
Constantinos Miltiadis
Evangelos Pantazis

CAAD Futures 2021 Open Call for Submissions

The theme "Design Imperatives: The Future is Now" is an instigation and reflection onto imminent matters that we are confronted with as designers, architects, planners, engineers, innovators, and policymakers of the living environment. More than ever, our discipline is facing challenging imperatives including rapid and pervasive digitization and automation, the overwhelming rate of data availability, the question of continuous growth as well as the diminished resources, and the impending environmental crisis. These are conditions that generate even greater degrees of uncertainty in conceiving design strategies.

Against this backdrop, the augmentation of new affordances and sensibilities into design practice is deemed necessary for the definition of new paradigms of architectural relevance.

Establishing a design practice capable of addressing both issues of the social and material world mandates the reformulation of computational design thinking, the renewal of our methodologies, and the reevaluation of frameworks for interdisciplinary synergy and social participation. Central to this new relevance is a critical, unambiguous, and active positioning against the face of pressing imperatives. As key considerations, we identified our global ecological health; our duty of care towards helping ourselves and future generations to better manage the planetary boundaries; and the betterment of the human condition at large as well as the support of resilient and sustainable architectural futures.

Under these circumstances, CAAD Futures 2021 aims to broaden its inquiry into the socio-economic, political, and environmental imperatives as they pertain to space, and the capacity of computational design to intervene. Extending this call, the conference intends to raise these issues within the design-computing discourse and foster synergistic relationships for their investigation through the lens of design. To instigate discussions we pose the following questions:

- What is the heritage of design computing and what futures can we imagine?
- Can the reconsideration of computational design thinking serve towards the formulation of a plan of action to address planetary crises underway?
- How does design maintain its disciplinary unity against the situatedness of its knowledge and the multi-modality of its practices?
- What is the future of design-computing practice within the architectural profession?
- How can we advocate for novel funding models and policies that foster scalable and responsible research in line with a resilient and ethical practice?

Organization

Organizing Committee

David Gerber (Chair)	University of Southern California, USA
Alicia Nahmad (Co-chair)	University of Calgary and R-ex, Canada
Biayna Bogosian (Co-chair)	Florida International University, USA
Constantinos Miltiadis (Co-chair)	Aalto University, Finland
Evangelos Pantazis (Co-chair)	IBI Group and Topotheque, USA
Thanasis Farangas (Assistant)	National Technical University of Athens, Greece

Keynote and Panel Speakers

Benjamin, David	Autodesk Research and The Living, USA
Buhlmann, Vera	TU Vienna, Austria
Ceccato, Cristiano	Zaha Hadid Architects, UK
Davis, Felecia	Pennsylvania State University, USA
Dimopoulos, Konstantinos	SAE Institute, The Netherlands
Farahi, Behnaz	California State University, USA
Hovestadt, Ludger	ETH Zurich, Switzerland
King, Jason	IBI Group, USA
Llach, Daniel Cardoso	Carnegie Mellon University, USA
Llaguno-Munixta, Maider	Princeton University, USA
Law, Stephen	Alan Turing Institute, UK
Luebkeman, Chris	ETH Zurich, Switzerland
Miltiadis, Constantinos	Aalto University, Finland
Maxey, Maddy	E-textiles, USA
Martinez Alonso, Nono	Autodesk Inc., USA
Moult, Dion	LendLease, Australia
Novak, Marcos	University of California, Santa Barbara, USA
Ochigame, Rodrigo	Leiden University, The Netherlands
Oesterle, Silvan	ROK, Switzerland
Parsons, Kate	Pepperdine University, USA
Sanchez, Jose	University of Michigan, USA
Standfest, Matthias	Archilyse AG, Switzerland
Sereshine, Shanuki	Alan Turing Institute, UK
Tsigkari, Martha	Foster + Partners, UK
Vardouli, Theodora	McGill University, Canada
Fok, Wendy	WE-DESIGNS and Pratt Institute, USA

Wachter, Maryanne	Independent Researcher, Switzerland
Orfanos, Yannis	WeWork, USA
Zamorano, Pablo	Heatherwick Studios, UK

Scientific Committee

The conference chairs would like to thank the following individuals for their contribution to the scientific process.

Achten, Henri	Czech Technical University in Prague, Czech Republic
Adel, Arash	University of Michigan, USA
Ampanavos, Spyros	Harvard Graduate School of Design, USA
Anzalone, Phillip	City University of New York, USA
Aparicio, German	Cal Poly Pomona, USA
Artopoulos, Georgios	The Cyprus Institute, Cyprus
Attia, Shady	Université de Liège, Belgium
Aviv, Dorit	University of Pennsylvania, USA
Baharlou, Ehsan	University of Virginia, USA
Bao, Dingwen	RMIT University, Australia
Bernal, Marcelo	Universidad Técnica Federico Santa María, Chile
Bogosian, Biayna	Florida International University, USA
Braumann, Johannes	Association for Robots in Architecture, Austria
Bruscia, Nick	University at Buffalo, SUNY, USA
Castellón González, Juan José	Rice University, USA
Celani, Gabriela	Unicamp, Brazil
Dan Zhang, Catty	UNC Charlotte, USA
De Azambuja Varela, Pedro	CEAU/FAUP, Portugal
Donohue, Mark	California College of the Arts, USA
Doyle, Shelby	Iowa State University, USA
Dubor, Alexandre	Institute for Advanced Architecture of Catalonia, Spain
Economou, Athanassios	Georgia Institute of Technology, USA
Erdine, Elif	Architectural Association, UK
Erkal, Emre	Erkal Architects, Turkey
Feghali, Yara	University of California, Los Angeles, USA
Fox, Michael	Cal Poly Pomona, USA
Fricker, Pia	Aalto University, Finland
Fukuda, Tomohiro	Osaka University, Japan
Gannon, Madeline	Carnegie Mellon University, USA
Gardner, Guy	University of Calgary, Canada
Gerber, David	University of Southern California, USA
Gerber, Andri	ZHAW, Switzerland
Gonzalez, Paloma	Massachusetts Institute of Technology, USA

Gonzalez de Canales, Francisco	Architectural Association, UK
Groenewolt, Abel	KU Leuven, Belgium
Han, Yoon J.	Aalto University, Finland
Herr, Christiane M.	Xi'an Jiaotong-Liverpool University, China
Herrera, Pablo C.	Universidad Peruana de Ciencias Aplicadas, Peru
Herruzo, Ana	Arizona State University, USA
Hosmer, Tyson	University College London and Zaha Hadid Architects, UK
Jones, Nathaniel	Arup, USA
Kalantar, Negar	California College of the Arts, USA
Kieferle, Joachim	Hochschule RheinMain, Germany
Kilian, Axel	Massachusetts Institute of Technology, USA
Kladeftira, Marianthi E.	ETH Zurich, Switzerland
Koehler, Daniel	University of Texas at Austin, USA
Koerner, Andreas	Universität Innsbruck, Austria
Kontovourkis, Odysseas	University of Cyprus, Cyprus
Körner, Axel	University of Stuttgart, Germany
Kostourou, Fani	University College London, UK
Kotnik, Toni	Aalto University, Finland
Koutsolampros, Petros	University College London, UK
Kretzer, Manuel	Anhalt University of Applied Sciences, Germany
Krishnamurti, Ramesh	Carnegie Mellon University, USA
Llaguno-Munitxa, Maider	Princeton University, USA
Maierhofer, Mathias	Universität Stuttgart, Germany
Manninger, Sandra	SPAN, USA
Marcus, Adam	California College of the Arts, USA
Marengo, Mathilde	Institute for Advanced Architecture of Catalonia, Spain
Marincic, Nikola	ETH Zurich, Switzerland
Martinez Alonso, Nono	Harvard University, USA
Mavasaityte, Rasa	University of Texas at Austin, USA
Mayer, Matan	IE University, Spain
Miltiadis, Constantinos	Aalto University, Finland
Mohite, Ashish	Aalto University, Finland
Morel, Philippe	EZCT Architecture & Design Research, France
Mostafavi, Sina	Delft University of Technology, The Netherlands
Nahmad, Alicia	University of Calgary, Canada
Orbey, Betul	Dogus University, Turkey
Orozco, Jorge	ETH Zurich, Switzerland
Ozkar, Mine	Istanbul Technical University, Turkey
Pantazis, Evangelos	Topotheque, Greece
Papanikolaou, Dimitris	UNC Charlotte, USA

Park, Hyoung-June	University of Hawaii at Manoa, USA
Peterson, Eric	Florida International University, USA
Petzold, Frank	Technical University of Munich, Germany
Pinochet, Diego	Massachusetts Institute of Technology, USA
Piskorec, Luka	Aalto University, Finland
Popescu, Mariana	ETH Zurich, Switzerland
Poustinchi, Ebrahim	Kent State University, USA
Puckett, Nick	AltN Research + Design and OCAD University, Canada
Ramirez, Jorge	Interela, Mexico
Reffat, Rabee	Assiut University, Egypt
Rockcastle, Siobhan	University of Oregon, USA
Roman, Miro	ETH Zurich, Switzerland
Romano, Christopher	University at Buffalo, USA
Santos, Luis	Kent State University, USA
Schneider, Sven	Bauhaus-Universität Weimar, Germany
Schwartz, Mathew	New Jersey Institute of Technology, USA
Scroggin, Jason	Scroggin Studio, USA
Senske, Nick	Iowa State University, USA
Slocum, Brian	Universidad Iberoamericana, Mexico
Smith, Ian	Ecole Polytechnique Fédérale de Lausanne, Switzerland
Soderberg, Catherine	Texas Tech University, USA
Standfest, Matthias	Archilyse, Switzerland
Stouffs, Rudi	National University of Singapore, Singapore
Sugihara, Satoru	ATLV, USA
Summers, Martin	University of Kentucky and PLUS-SUM Studio, USA
Symeonidou, Ioanna	University of Thessaly, Greece
Tucker, Shanta	Atelier Ten, USA
Vardouli, Theodora	McGill University, Canada
Verebes, Thomas	New York Institute of Technology, USA
Vermillion, Joshua	University of Nevada. Las Vegas, USA
Walmsley, Kean	Autodesk Inc., USA
Wiltsche, Albert	Graz University of Technology, Austria
Wit, Andrew	Temple University, USA
Xydis, Achilleas	ETH Zurich, Switzerland
Zacharias, Maroula	Harvard Graduate School of Design, USA

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