



Architecture In-Play: Digitally-Driven Kinetic Origami Architecture

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Abstract This Letter from the Editor presents an overview of the special issue's theme, Architecture In-Play, and its focus on digitally enabled, kinetic architecture. The original catalyst for this issue was an international conference on this topic, which was held between the 11th and 23rd of July 2016 at ISCTE–Instituto Universitário de Lisboa, Lisbon, Portugal. The Letter from the Editor includes an introduction to the five papers that make up the special issue.

It is a great pleasure to present special issue 20(1) of the *Nexus Network Journal: Architecture and Mathematics*, which is dedicated to digitally driven, kinetic origami architecture. This topic is widely recognized as an important one in contemporary architectural research and practice. The emergence of digital workflows support the opportunity to increase computing capacity in design. The paradigm shift encapsulated in this change is opening up opportunities for making architecture more responsive, adaptive, interactive, sensitive and smarter. As a result of these changes, architecture should be able to evolve and adapt to user's needs through the use of digitally driven sensor-actuator devices that can allow a flexible and dynamic range of shapes and geometries within an object, in order to transform space rapidly, interact and communicate with its inhabitants. This level of performance might be programmed to address a variety of design goals from aesthetic to functional, from speculative to reality, from individual to social, or from emotional to environmental. Kinetic architecture seeks to incorporate collective creativity beyond individual disciplines. The call for interdisciplinary relations

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necessarily requires a detailed understanding of their specific modes of inquiry and knowledge production.

In this context, from the 11th to the 23rd of July 2016, the ISCTE–Instituto Universitário de Lisboa—hosted an International Conference entitled “Architecture In-Play”, which sought to capture a global perspective of the current status in research and practice in kinetic design studies as well as its integration into programs for architectural training. The event was organized in partnership with La Sapienza Università of Roma. The purpose of the event was to think about an interdisciplinary architectural approach, about its tools, methods and theories, and to help to bring together people from all the fields who can merge and create digital architecture. The call was intended to focus attention on the study of geometry, in particular origami, and rethink user-centred interaction in architecture throughout digitally driven customization of environments.

The conference organizers—Alexandra Paio, Filipa Osório, Sancho Oliveira, Graziano Mario Valenti and Nuno Guimarães—have collectively contributed the first paper in this issue entitled “Architecture In-Play, future challenges”. This paper serves as an overview of the field and introduction to the guest speaker at the conference, each of whom discussed a particular aspect of the digitally driven kinetic origami architecture. In addition, this paper describes the surfaces in-play summer school design studio, its overall process and results.

Four of papers presented at the conference were selected for development and review, prior to being included in the present issue of the *Nexus Network Journal*. They were selected in order to capture a number of representative developments in the field across two domains: (1) origami kinetic research studies; and (2) kinetic design studio experiences in architectural education in schools.

The paper by Mia Tsiamis, Alfonso Oliva and Michele Calvano, “Algorithmic Design and Analysis of Architectural Origami” looks at origami tessellations to adapt them to free-form surface configurations in the context of architectural and engineering applications. The researchers present the relationship between miura-ori origami pattern variables, the subjacent folding geometry and the structural behaviour on an architectural scale. A mathematically driven design approach is used to generate the geometry of the folded origami plate structures. The authors focus their attention on the study of geometry, in particular on origami ruled surface patterns and their possible parametric folding variations. This contribution explores a parametric workflow that offers a platform for evaluating the effect of the miura-ori fold pattern. This application of geometry is oriented to the conceptual formal and expressive control of built form. The paper discusses models that can assist in experimental testing and are useful instruments for showing how the research was carried out.

Alessio Mazzucchi’s “A Kinetic Module for Modular Structures Based on Rigid Origami” addresses the potential of exploiting rigid origami triangular Resch’s tessellation properties, to create a reusable, adaptable modular kinetic structure in architecture. This paper frames the notion that computational power is expanding the ability of architectural researchers to manage and think through complex conditions with different forms of linking data. Today’s architects have been able to expand the discipline’s limits, both in terms of form and performance. The

fundamental question is, how can the organization of information in this new digital technique be encapsulated in the design process? To address these competing demands, Mazzucchi presents a generic digital workflow for managing design information from folded origami geometry (logic, production rules and patterns) to kinematic. The main goal is to create a digitally driven origami kinematic modular system which is able to translate any rigid origami tessellation into a fabricated modular structure.

Andrew Viny, Avanti Dabholkar and Daniel Cardoso Llach's paper "Two Design experiments in Playful Architectural Adaptability" focuses on design projects related to teaching practice at the Carnegie Mellon School of Architecture. This paper offers new perspectives on architectural education, presenting design workflows which allow architectural objects and spaces to interact with human inhabitants in playful behaviour. This paper presents two examples of a hybrid design pedagogy that combines architectural design thinking and innovative computational methods. The first explores multi-modal design to develop a customized prototype of an interactive chair. This approach promotes playful user-participation in the collaborative design creation process. The second example, biometric architecture, uses biometric data derived from the human body to dynamically transform the experience of architectural space. The second approach suggests that it is possible to use biometric data as a generative space-making tool. These experiments expand the discourse and boundaries of design interaction and responsiveness and offer support to transdisciplinary project-based design pedagogies.

The paper by Syuko Kato Westby and Ruairi Glynn, entitled "Fabricating Performance: Reciprocal Constructs of Dance Notation" is about the analogue and digital relationship between architecture and bodily choreography and movement in the construction of space design. The design research project was produced as part of teaching and training practice at the Bartlett School Interactive Architecture Lab UCL. This research combines body tracking and gesture recognition techniques with robotic performance and fabrication. The data-driven fabrication combined with performance-driven design contributes to discuss about both interactive representation of bodily behaviour and geometry in the digital age. Performance-driven design enables the translation of body behavioural rules in design through the geometrical form by way of digitally written scripts. Data-driven fabrication enables the translation of synchronous movement into robotic assemblies. The work described in this paper aims to demonstrate how a "corporeal" view of contemporary architecture will be able to construct a novel spatial notion. In summary, it demonstrates how interactive drawing notation might become a more dynamic tool and one which supports construction, based on the inhabitants' behaviour or actions.

The subjects of interest and inquiry represented by the approaches selected for this issue of the *Nexus Network Journal* demonstrate the potential of digitally-driven kinetic origami architecture in a world where computational tools will streamline and increasingly disrupt the architectural design and research practices. All of these developments will transform design thinking processes and procedures, delivery methods, fabrication approaches and construction. The goal of this special

issue is to help shed light on some of these challenges and to put forward new ideas to support a fruitful discussion.

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