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Forces

Guest Editor: Odysseas Kontovourkis[1]
Department of Architecture, University of Cyprus
[1] kontovourkis.odysseas@ucy.ac.cy

This issue of ArchiDOCT e-journal revolves around the notion of "forces". "Forces" have been revived, for their key role, in contemporary contemplations of architecture conceived as a complex and speculative process of dynamic interactions amongst agents involved in an ecology. "Forces" are met in both deterministic, top-down processes of form generation and they can be generative in bottom-up, emergent form generating scenarios and narratives. Literally or metaphorically, consciously or unconsciously, the notion of "forces" lies at the heart of decision-making, simulation, control and physical realization of urban, architectural, structural and material systems in the built environment. Most importantly, however, it is their ability to trigger changes of existing situations, to reformulate, to revive, to regenerate and to renew existing material or immaterial systems in a way that their optimization and renewal, in virtual and physical space, can be achieved. They drive, shape and influence design decisions on both theoretical and practical levels and at various scales. "Forces" can become activation principles, as they may be determined by aesthetic, sociological, economic, ecological, geopolitical, constructional, media, networks, data or other influences. They may span from "social forces" used to explore interactive relationships between humans and/or machines, to "topology optimization" methods whereby the best distribution of forces and material in a system can maximize structural performance. The importance of "forces" can be found in exploring architectural and structural systems' efficiency, buildability, virtual simulation, interactive attraction or repulsion and so on, always aiming to redefine and renew an existing state towards a new improved form of existence. This can be done by any means, analogue or digital, allowing users to activate such forces, through which the results can be interpreted, revisited and implemented. This ArchiDOCT issue contains papers that explore the concept of "forces" in theoretical and practical terms and highlights the breadth and scope of the results their implementation can bring about. The issue includes one good practice example and five essays related to doctoral research activities worldwide.

The good practice example titled "Path systems connecting forces, materials and robotic tools. Integrated computational design and robotic fabrication workflows" has been written by the Guest Editor of the issue, **Odysseas Kontovourkis** from the Department of Architecture, University of Cyprus. The paper examines the role of path systems in architecture through examples found in nature and discusses the work by Frei Otto in relation to the development of optimal path systems using physical models. The examination of computational methods for path systems' form-finding and the work done by author on "virtual force" modeling is exemplified, while the ability

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of path systems to provide seamless connection of forces, materials and robotic tools is emphasized. This idea is further supported through two integrated computational design and robotic additive manufacturing research workflows for the development of tensile mesh structures and building components using polyurethane elastomeric and clay-based materials respectively.

The first essay by **Ghali Bouayad** from Graduate School of Fine Arts, Department of Architecture, Tokyo University of The Arts, describes his doctoral research work titled "Three-dimensional translation of Japanese Katagami patterns. An investigation through agent-based algorithms applied to architectural elements and space planning". This work investigates design possibilities by adopting a methodology, where Japanese Katagami patterns are translated into three-dimensional spatial morphologies and architectural configurations through the implementation of agent-based algorithms with focus on flocking behavior. Within this framework, a series of case studies and respective parameters influencing the results are exemplified, accompanied by possible design applications. This work attempts to provide an approach that allows greater freedom in creating unpredictable and unconventional space formation in the early design phase, and at the same time opens possibilities for investigating alternative architectural planning solutions.

The second essay "Environmental aware shell design. Using solar paths as a form finding force" is authored by **Evangelos Pantazis** from the Viterbi School of Engineering, University of Southern California. In his doctoral research work a design methodology and a toolkit is proposed for the form-finding of shell structures using multi agent systems, together with the introduction of environmental parameters and particularly daylight as a shaping force apart from typical loads. The suggested methodology is tested using an existing thin shell concrete structure design by H. Isler, showing possibilities for developing different topologies. The results of experimental design demonstrated in this paper shows that it is possible to extend the traditional form-finding techniques and find solutions that fulfil both structural and environmental performance objectives. Also, this methodology allows generation of designs and visualization performance metrics by designers.

The third essay of this issue titled "Behaviour and performance analysis against gravitational loads of a non-traditional, precast, removable and reusable shallow foundation" is authored by **Juan José Rosas Alaguero** from the ETS Arquitectura del Vallès, Universitat Politècnica de Catalunya. In this paper, results derived from the investigation of the function of a non-traditional foundation typology, which can be prefabricated, mountable, removable and reusable, are presented. Particularly, the analytical tool for calculating the resistance of the suggested foundation against vertical loading is demonstrated by combining two traditional resistance mechanisms of analysis. Specifically, the research conducted in this paper focuses on the analytical approach for testing solutions, on numerical simulation and on experimental verification of loading tests. The process allows verification of the results and determination of the ultimate capacity of the suggested foundation to be on the safe side.

The forth essay by **Panagiota Konatzii** from the Department of Architecture, University of Cyprus, describes her doctoral research work titled "Static performance-

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oriented design of variable modular bricks for automated fabrication using an adaptive formwork". This paper is part of an ongoing work on the development of an automated fabrication process for the production of multi-modular bricks in various typologies using a suggested adaptive formwork. Specifically, in this paper emphasis is given on morphological and static criteria based on three different materials; adobe, concrete and clay mixture. Through the research study, a comparison is made between different modular typologies and material volumes and their compressive strength. The aim to evaluate the results and find desirable modular brick typologies during the early design stage, aiming at minimizing materials and maximize static adequacy. In addition, the suggested methodology provides a framework where integration between performance-oriented design and kinetic and flexible formwork mechanisms can be achieved.

The fifth essay "(De)constructing and analysing a joint" is authored by **Hector Cantos Coronel** from the ETS Arquitectura del Vallès, Universitat Politècnica de Catalunya. In his doctoral research work a pin joint is developed with the aim to be easily fasten in order to support the stresses of a conventional hexagonal structure. Analytically, this work aims at the prefabrication of a structure based on an Hexagrid configuration, examining in parallel its possibility to be folded, transported, deployed and assembled though the introduction of a pin joint. This paper consists of different parts dealing with geometric functional design and validation of structural resistance through which stresses and deformation are analyzed using finite element model. Also, it includes results of detailed design in order to demonstrate the foldability of the suggested pin joint and the structural system. The paper stresses the importance of prefabrication and transport that can be achieved through the suggested joint but also the necessity for a right balance between the resistance of parts and the simplicity of the design.