Innovative Puzzles

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Matter and information; information and matter. A puzzle unveiled little by little. Hardly surprising since every atom, molecule, and basic particle in the universe registers bits of information. All interactions between these components, inert and alive, owe their existence to matter’s intrinsic ability to process information. Such aptitude explains how complex systems can arise from fundamentally simple organizational laws. In fact, the world’s almost infinite material combinations, viable through such few basic elements, are one of the most visible expressions of these capabilities. Triggered by the developments in quantum physics across the twentieth century, our understanding of material processes radically shifted our impressions of the world. For decades our scales of perception and manipulation have continued to expand into almost unfathomable boundaries. Yet, the study of the interdependencies between matter and information is still fundamentally part of the sciences and engineering. Only just recently did architecture venture into this inherently intricate field. The subsequent set of papers here presented posit fundamental interrogations of potential interdependencies between matter and information. Without fear to confront the obstacles of delving into a largely unexplored field of architecture, these researchers forge new frontiers of interrelating computational parameters to multi-physics in the complex settings of architectural scale. Unlike other epistemologies, architecture cannot be reduced to a single scale of exploration. We can neither restrict scalar boundaries (i.e., nano to micro), nor reduce morphologies to simplify the processing of multiple physics without compromising the design problem. By default, it is more difficult to conceptually and numerically articulate the abstract and numerical criteria of complex geometries and material variables.

Form does not exist without matter. Matter does not exist without form. For even in graphene, the smallest material yet developed at only one atom thick, the performance breakthrough (strength, conductivity, lightness) is provided by its singular crystalline organization. Low-dimensional physics is enabled by a unique molecular structure and “form.” As with all materials and live organisms, the organizational structures from atomic-scale upwards, expressed through geometries, constitute the set of material properties. Consequently, that architecture should venture into exploring more congruent cross-pollination between matter, structural organization, and geometry is beyond dispute; as is the critical and creative exploration of the potential that computation bears in this exercise. The first essay by Achim Menges discusses precisely this subject matter. The author explores the integration of material behaviors in the computational design process by critically questioning the ubiquitous gap between material properties and form generation. Menges acknowledges the underutilization of intrinsic system characteristics, such as material properties, as its primary limitation. Using wood as a framework, the author explores material properties such as the unique bending characteristics of an anisotropic structure, within the further constraints of robotic manufacturing through three distinct projects. The research brings forth a breakthrough foundation. It enables the verification of computational designs by comparing the proposed model with both FEM (finite element methods) simulations and the actual measurements of life-scale physical prototypes. Precisely defined feedback loops between the prototypes and computational systems open conceptual and digital scenarios of robust integration between design computation and materialization. A theoretical expansion to this discussion is subsequently presented by Ahlquist and Menges. The essay evaluates the relevance and potential of iterative validation processes, based on system principles and integrative mechanisms, in realizing the value of physics-based methods as information engines. By putting to question the limitations of digital explorations bound to representational
characteristics, the authors analyze the fundamentals of performance-based integrative methods that look into the very essence of computational design rationale. The analysis highlights the interdependence between what they conceptualize as the three basic structures of behavior-based computational design: system principles, system simulation, and system behavior. The interaction between these three components creates value through an iterative process that renders precise digital simulation models.

Interrogations of current material innovation trends, mainly CNC fabrication and material science, often characterized by total technical control or material purity, are presented by Fure’s article. The author proposes an alternative model called “Digital Materialurgy” that seeks to facilitate novel innovations by intentionally ceding limited design control to what he denominates “eccentric matter.” By relinquishing some control to matter, properties such as textures, shapes, and colors, are given freedom to generate unexpected formal and material complexity. In this formulation, Fure argues, materials are no longer subservient to design and constrained by tolerances; instead, materials become dynamic agents guided by a framework of digital and computational codes. By sacrificing some level of conventional notions of material control and homogeneity, the author argues that the space between the coded and the chaotic can be alternatively examined.

The last two essays evaluate the analogous role of physical prototypes. By confronting physical representational models to active research tools for form finding, these essays unhang a critical overview of material and digital integration. The melding of analog machines to a conceptual scaffold focusing on “form, force, and matter” is set by Parsons and Akos’ text. “Form-Active Systems” as defined by the authors, are characterized by the direct engagement with material, which is utilized for its ability to reconfigure under pressure to maintain stable forms. Such engagement views form, force, and matter as interrelated and active agents within the process of stabilization. From this conceptualization, scale is no longer merely representational, but a design mechanism for stabilizing the physical transformations of form-active systems. Another perspective on form-active models is introduced in the last essay of this series by Andrew Kudless. He carefully traces the evolution of flexible formworks as it relates to design strategies that integrate form, fabrication, and material behavior. Kudless argues that these material practices operated at times counter to the mainstream of Modern movement, seeking instead the higher integration of form, fabrication, and material performance. The author vividly articulates form-finding, understood as an experimental process that uses the self-organization of material under force to discover stable forms. A refreshing view into the interdependence of mold and infill is articulated through the P_Wall project where system constraints negotiate the complex physics between a flexible framework and the fluid plaster slurry.

Material technologies are evidences of culture, time, and means of innovation. If we accept that innovation is contingent in the sense that it does not follow an absolute or universal standard, as well as, possible at all levels of action, then what traits make improvement ephemeral or sustained? Indelibly guided by necessity, a culture of innovation intrinsically fosters the exercise of improvement by delving into new experimentation methods and collaborations. The essays presented in this session transverse these spheres. From Menges’ integrative iterations of large-scale, digital, and simulation studies as validation processes of material behavior, to Kudless’ uncommon post-evaluation of a digital prototype (P_Wall) after tangible weathering, crucial aspects of material and informational intersections and discussions are established by these essays.

Future explorations of matter and information in architecture will cease to be limited to traditional scales of research. The next years are bound to experience an expansion into unimagined smaller scales. Streamlined integrations of micro lab productions into construction-scale fabrication technologies generated by unforeseen interdisciplinary collaborations will be pivotal to the frontier of Computation, Formation, and Materiality. Architecture is yet at the inception of material and computational puzzle making and solving.

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