Digitally-Driven Architecture

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The shift from mechanical to digital forces architects to reposition themselves: Architects generate digital information, which can be used not only in designing and fabricating building components but also in embedding behaviours into buildings. This implies that, similar to the way that industrial design and fabrication with its concepts of standardisation and serial production influenced modernist architecture, digital design and fabrication influences contemporary architecture. While standardisation focused on processes of rationalisation of form, mass-customisation as a new paradigm that replaces mass-production, addresses non-standard, complex, and flexible designs. Furthermore, knowledge about the designed object can be encoded in digital data pertaining not just to the geometry of a design but also to its physical or other behaviours within an environment. Digitally-driven architecture implies, therefore, not only digitally-designed and fabricated architecture, it also implies architecture - built form - that can be controlled, actuated, and animated by digital means.

In this context, this sixth *Footprint* issue examines the influence of digital means as pragmatic and conceptual instruments for actuating architecture. The focus is not so much on computer-based systems for the development of architectural designs, but on architecture incorporating digital control, sensing, actuating, or other mechanisms that enable buildings to interact with their users and surroundings in real time in the real world through physical or sensory change and variation.

Digitally-driven architecture points to a paradigm shift from inanimate towards animate structures. Consider, for instance, the nodes of a networked structure pertaining to a building as being a distributed system of digitally-driven sensor-actuator devices. The resulting behaviours of this 'swarm' of digitally-driven devices can allow for a flexible and dynamic range of shapes and geometries within a building, even changes in materials or sensory behaviours, within varying time frames. These behaviours might be programmed to address a multitude of needs or goals from personal to societal, from aesthetic to functional, from emotional to environmental.

Flexibility and dynamic change of shape might, for example, address a range of time-sensitive issues: from local issues relating to the inefficient use of built space to global issues relating to catastrophic conditions or rapid urbanisation.[1] On a local scale, inefficient use of built space results from mono-functioning neighbourhoods such as ones comprised of office buildings that are deserted at night and residential neighbourhoods that are deserted during the day. On a global scale, natural disasters and other catastrophic or emergency conditions caused by earthquakes, hurricanes, war, and so on often result in population migrations as communities abandon their homes and seek shelter elsewhere. Also on a global scale, rapid urbanisation implies the need to address the problem of potential over-population and increased housing demands at urban and architectural levels. For all of these situations, new

solutions might be found in digitally-driven reconfigurable, extensible, or resizable structures that permit multiple, rapidly changing, and adaptable uses.

Digitally-driven architecture, as defined here, embraces a wide spectrum of design possibilities and nomenclatures - kinetic, adaptive, responsive, intelligent, interactive, and more. As the authors in this issue point out, the foundations for much of the work that comes under these headings today can be traced back to the mid-20th century work of cyberneticians on systems adapting to continuous feedback from the environment. Then in the 1960s, cybernetic ideas were taken up in Archigram's vision of indeterminate architecture - architecture that could respond to open-ended and uncertain conditions. In the 1970s, Zuk and Clark[2] attempted to introduce physicality to earlier theoretical propositions with their proposals for a new, kinetic architecture. They imagined transformable buildings able to change their physical geometries: auditoriums and stadiums with movable seating and retractable roofs, and pneumatic, revolving structures for modular buildings that were able to expand incrementally. At the same time, researchers continued to push cybernetic ideas in architectural directions. Eastman, for instance, envisioned spaces and users as feedback systems that would allow architecture to self-adjust to fit the needs of users.[3] Today, technological and conceptual advances in fields such as artificial intelligence, robotics, and materials science have enabled some of these early visionary ideas not only to be realised physically but also to be taken in important new directions. Kinetic architecture incorporating structural movement, and responsive or interactive architecture incorporating communication and real-time feedback between structure and user/environment have been materialised in recent innovative prototype projects from dECOi's Aegis Hypo-Surface to Hyperbody's Muscle Projects to ORAMBRA's Actuated Tensegrity Structure to Verschure's ADA Intelligent Space.[4]

The five papers that comprise this issue thus reflect a diversity of contemporary attitudes and responses to the challenges and potentials of digitally-driven architecture today and for the future. Through critical reflection, as well as built prototypes and projects, the authors of these papers interrogate the many dimensions of digitally-driven architecture. The issue opens with an 'introspective-retrospective' of the field by Michael Fox, a leading contributor to interactive design since the mid-1990s. Fox unfolds the history of interactive environments by taking us on a personal journey of the evolution of his own thinking and design practice in the area. The story he tells is a story of 'Catching Up with the Past'. The past here begins with cyberneticians Norbert Weiner and Gordon Pask and architects Cedric Price and John Frazer, who imagined machines and buildings as living, adaptable organisms in dynamic relationships with their environments. Fox's journey takes off from this heritage with a re-examination of kinetic - physically reconfigurable - architecture, and then progresses through a series of creative explorations that build incrementally on emerging technological ideas and innovations: automated kinetic systems with embedded, computational control devices; decentralised control systems; emergent, bottom-up control; modular, robotic control systems; biometic control processes; and finally, today, nanoscale bio-robotic control systems that drive all manner of physical and sensory adaptation at the level of materials. The overall trajectory is an advance towards the past - from a mechanical paradigm for interactivity to an organic, holistic one that begins to realise early cybernetic ambitions.

Fox's look back at interactive design is encapsulated in an elegant project by Daniel Rosenberg described in his paper 'Indeterminate Architecture: Scissor-Pair Transformable Structures'. Along the lines of Fox's advance to the past, Rosenberg aims to 'materialise and radicalise the seminal ideas' of pioneering cyberneticians and architectural theorists. He develops a novel, transformable

(scissor-pair) structure that displays non-uniform, indeterminate mechanical behaviour. He then shows how this structure can be actuated in real time, and its form and behaviour 'radicalised', using recent AI techniques for robotics. The resulting digitally-controlled structure is able to 'sense', record, and learn from its own performance and interaction with users and the world, and adapt its behaviour accordingly.

Like Fox, Sokratis Yiannoudes takes a long view of kinetic and interactive design. However, Yiannoudes lays aside technological and functional considerations, and examines, instead, the historically-situated, socio-cultural drivers of this work. He argues compellingly that digitally-driven architecture is motivated by a long-standing, cultural, and perhaps psychological, need to comprehend and negotiate the boundaries between the animate and inanimate, between human and machine. Yiannoudes builds a novel conceptual framework for understanding digitally-driven architecture - often perceived as alive, social, emotional - based on Turkle's 'marginal object' concept viewing computers and computational objects as metaphorical and mechanistic and situated 'marginally' at the limits between living and non-living.[5]

Yiannoudes's framework is exemplified nicely in design projects described by MarkDavid Hosale and Chris Kievid in their paper 'Modulating Territories, Penetrating Boundaries'. They present an architectural installation, the InteractiveWall, with multi-sensory, real-time behaviours inspired by natural phenomena and triggered by internal and external stimuli. Sound, light, and movement combine to produce the semblance of a sentient, social being. The aesthetics and technologies behind the InteractiveWall were extrapolated in the Dynamic Sound Barrier - a real-world design proposal for an outdoor sound barrier that is activated and reveals itself in a landscape only in the presence of noise. Thinking beyond these projects, Hosale and Kievid raise important issues to do with current building and construction regulations that constrain architecture to static configurations. In this context, interactive architecture is seen as creating a demand to redefine architectural regulations and to engage architects in the design of new legislation for building.

Charlie Gullström expands the discourse and boundaries of digitally-driven architecture and rounds out this issue with a paper entitled 'Mediated Windows: The Use of Framing and Transparency in Designing for Presence'. Gullström uses a museum installation as the platform for a wider investigation into perceptual - as distinct from mechanical and physical - adaptation and interactivity. Her installation of digitally-'mediated windows' at a museum and a related outdoor site enables simultaneous, audio-visual extensions from one space to the other. Gullström addresses the historical relevance and implications of this form of interactivity - often missed in the discourse on contemporary technological applications - through a close examination of visually-extended architectural spaces in art and architecture. She explores the shift from the singular, window view and its historical depictions, to the digital, mediated window allowing for multiple views and modes of interaction.

While the theoretical issues raised by the papers in this issue help position digitally-driven architecture within a larger conceptual framework, the built prototypes and projects begin to demonstrate the potentials of digitally-driven architecture for the built environment and society at large. Following up on futurist visions of the 1960-70s and incorporating technological developments of the 1990s and later, digitally-driven architecture has broken with the modernist past on ideological, methodological, and typo-morphological levels. If top-down, programmatic function layout as well as standardised, serial-production determined typo-morphologically modernist buildings confined to static, modular, repetitive spatial configurations, then flexible,

bottom-up, reconfigurable structures release built form from these confines. New responses to architecture's economic and ecological impacts (for example, with more efficient footprints) are now possible with the development of unprecedented concepts and their applications in digitally-driven architecture. Digitally-driven architecture accommodates human needs by addressing imperative requirements for flexibility and reconfiguration; equally important, it transcends pragmatic needs by instigating new evocative and 'emotive' relations with the built environment.

Notes

1. Archibots at UBICOMP 2009, Workshop group #4 <http://www.archibots.org/> [accessed 20 April 2010]
2. William Zuk and Roger H. Clark, *Kinetic Architecture* (New York: Van Nostrand Reinhold, 1970).
3. Charles Eastman, 'Adaptive-Conditional Architecture', in *Design Participation: Proceedings of the Design Research Society's Conference Manchester*, September 1971, ed. by Nigel Cross (London: Academy Editions, 1972), pp. 51–57.
4. ADA <http://ada.ini.uzh.ch/>, ORAMBRA - PROJECTS <http://www.orambra.com/>, HYPOSURFACE <http://www.hyposurface.org/>, HYPERBODY - MUSCLE PROJECTS www.protospace.bk.tudelft.nl/ [accessed 20 April 2010]
5. Sherry Turkle, *The Second Self: Computers and the Human Spirit* (Cambridge, MA: MIT Press, 2005).