The Automation of Architectural Production: Towards Collaborative and Coordinated Models of Practice

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Automation in Architecture

Architecture has a fundamental responsibility to not only respond to, but actively shape the public realm and the behaviors of its inhabitants. It therefore also has the responsibility to propose and introduce models that reflect the challenges of their times, and provoke the questioning of the status quo. Presently our built environment is one of inequality and exclusivity, as evidenced by global housing crises and neoliberal politics that favor a privatization of common spaces for the benefit of the capitalist market. However, by not using our technological possibilities for the proposition of fundamentally changed models of designing and building, but rather the perpetuation of architectural singularities and complex geometries entangled in the deceptive, infinite variation of mass-customization, architects are currently failing to challenge these developments in a holistic, cross-disciplinary manner.

It therefore seems timely to investigate how the digital tools that have become ubiquitous in the architecture, engineering and construction (AEC) industries for design, visualisation and project management can become activators for a shift within a wider context of the need for better labor practices, more sustainable construction processes, and a built environment that benefits the many, not the few. Since the dawn of the "Age of Automation" with the establishment of the "automation department" at Ford in 1947,[1] automated technologies have been introducing new workflows and modes of production across industries, yet these developments have so far not been taken up by the AEC industries.

In the current context of changes to our ways of living due to COVID-19 especially, the shortcomings and systemic inequalities of current models in both architecture and its wider context are even more starkly highlighted, and their behaviors have proven themselves unable to adapt. As a discipline, architects need to heed this wake-up call to work towards an environment that encourages collaboration over competition, as well as a new model for the architectural discipline that operates from the bottom-up while retaining a working system of coordination within the core structure of its formulated design ideas.

As Kiel Moe points out, there is a need for "a new model of models" which elicit new behaviors in architecture and our collective systems.[2] Space values and social patterns are changing, perhaps permanently. It stands to reason that housing production needs a different paradigm in contemporary architectural production: one that answers to adaptation instead of making its users adapt. In turn, this could result in a changed model of how we are utilising digital design and fabrication technologies.

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[1] Jeremy Rifkin, *The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era,* (New York: Putnam Publishing Group, 1995), 66, 75.

[2] Kiel Moe, "Our Model of Models in the Anthropocene" , *The Journal of Architecture*, Volume 21, Issue 8, Architectural History in the Anthropocene (2016): 1299-1311,DOI: 10.1080/13602365.2016.1256906

Digital Architecture?

Currently, such technologies are often described under the umbrella term "digital architecture." But this is problematic, with voices in the field arguing that such architecture doesn't exist[3], and we have never actually been digital in our practice.[4] This often-perpetrated "paradigm" is therefore not a paradigm, but rather a collection of methods that architects have come to adopt in their workflows. Even more dangerously, these methods and terminology have also been appropriated, contextualized and politicized by positions such as Patrik Schumacher's "parametricism",[5] which argues for neoliberal spatial politics of deregulation and privatisation,[6] which further exacerbates the inequities in labour and production.

One of the main places where the "digital" actually has proliferated is therefore not in architecture or design, but in economic models where companies like Uber, Facebook, Tencent, Alibaba, Amazon, Google and WeWork are changing the ways we live, work, move and communicate. There is a disconnect between the fundamental rethinking of structures in such models and past decades of architectural work focused around the adoption of digital tools. The late 1990s and early 2000s were mostly interested in the potential for infinite variations of self-similar objects with the possibility to produce these at almost the same cost as mass-standardised objects using automated methods, and hence the subversion of the economies of scale that defined the industrial era.[7] However, this approach does little more than enlist a digital tool with a mechanical task, automating the act of cutting parts of a complex digitally-designed object. It fails to consider the articulation of the object itself to be in a feedback loop with the machine in the design process, and therefore detaches it from its digital generation. As Skylar Tibbits points out, *"[...] architects have collectively pushed the boundaries of mass-customised complexities, producing thousands of unique components requiring thousands of connections that demand hours, days, months or even years of manual assembly."*[8] If automation is a model for design production, the virtual-physical interface needs to be at the center of discourse.

Proposing a New Model

Therefore, automation problematizes and critiques the consequences of these contexts through two main concepts aimed at uniting the idea of "the digital" in architecture around a closely connected model of design and fabrication. The first is the *assembly problem,* or the inability of existing approaches to automated design strategies to reconcile effectively with existing building practices, as Tibbits outlines above. The second is the *automation gap,* or the lack of innovative solutions in construction automation around social practices in architecture and construction, or to think imaginatively about issues regarding labor, technology and production. This contextualization and interweave of issues in our societal systems positions automation as the

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[3] Neil Leach, "There is No Such Thing as Digital Design", in *Paradigms in Computing: Making, Machines, and Models for Design Agency in Architecture,* eds. David Gerber & Mariana Ibanez (Los Angeles: eVolo Press, 2014), 148-158.

[4] Gilles Retsin, "*Discrete and Digital",* (unpublished, TxA Conference, 2016)

[5] Patrik Schumacher, "Parametricism as Style - Parametricist Manifesto", December 2008, http://www.patrikschumacher.com/Texts/Parametricism%20as%20Style.htm

[6] Patrik Schumacher, "Housing as architecture," (Keynote, World Architecture Festival, December 2018)

[7] Mario Carpo, *The Second Digital Turn: Design Beyond Intelligence* (Cambridge: MIT Press, 2017), 6.

[8] Skylar Tibbits, "From Automated to Autonomous Assembly", in *Architectural Design*, Volume 87, Issue 4, Autonomous Assembly: Designing for a New Era of Construction (Cambridge: Wiley, 2017), 8

suggestion of a new model beyond architectural production in line with Kiel Moe's call for a new "model of models"[9] for the Anthropocene.

Automation as a model requires its actors to argue that an anthropocentric society needs to move beyond the production chains, processes, and concepts of work that were born out of the Industrial Revolution. By addressing the disconnect between digital design production and the traditional construction industry, the robotic building model also necessarily addresses the lack of digitization and stagnating productivity in construction[10] which need to be considered a deciding factor in the global housing crisis. To close the automation gap here necessitates an emphasis on the economic and social responsibilities of design politics in the field of architecture, and it must be considered that in its current manifestations, automation often tends to adversely affect those who are disadvantaged more significantly[11]. For example, existing Modern Methods of Construction (MMC) that aim to implement automation and prefabrication for housing development generally do so by centralizing their production in off-site factories which disconnects them both from the context they are deployed in, and from local employment and economic development. A true automation model needs to argue for solutions that enable participation of communities and provide a suite of tools for robotic building with low-threshold accessibility. By contextualizing itself in this manner, automation can empower local trades and supply chains and address assembly problems through the augmentation of building practices and fostering of complementary workflows between humans and technology. However, with a returning focus to the virtual-physical interface, design practices themselves will also have to move away from a contentedness with "being digital", to using the digital in a more holistic manner by arguing for agile design systems instead of one-off solutions. Such systems need to place a focus on accessible, easy to use design/assembly software and guidance, as well as geometries that allow for adaptation, reuse, and straight-forward fabrication in standard workshops. In combining these factors, the automation model proposes a collaborative, inclusive approach to MMCs that emphasize sustainability, short production chains, and an inherent focus on their context.

Discrete Automation

The practice Automated Architecture (AUAR) designs instances of behaviors within the automation model, using discrete parts (self-similar elements with universal connections, similar to Lego blocks) and renewable resources, such as timber. As a whole, discrete automation is based on the principles of digital materials, or the facilitation of reversible assembly of discrete sets of components.[12] Discrete parts dissolve the traditional assignment of function to building parts--any given system consists of a very limited number of geometrically different parts with universal connections that can become stairs, columns, floor slabs, and so on, depending on their

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[9] Moe, "Model of Models"

[10] Filipe Barbosa et. al, "Reinventing construction through a productivity revolution", *McKinsey Global Institute,* February 27, 2017, https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution#

[11] Benjamin, Race After Technology, , and Virginia Eubanks, Automating Inequality - How High-Tech Tools Profile, Police and Punish the Poor (New York, St. Martin's Press, 2018)

[12] George A. Popescu and Neil Gershenfeld, "Digital Materials", 2009, https://www.researchgate.net/profile/George_Popescu4/publication/228430160_Digital_Materials/links/56aa26c508ae7f592f0f2145/Digital-Materials.pdf

position in the design (Fig.1). The scale of the parts can be variable, but they tend to retain one size throughout individual iterations. One such system, Block Type A for example, uses one size of timber "box" that is joined with others using steel rods, nuts and bolts at repeating, predefined connection points (Fig. 2). The system is therefore reversible and adaptable by increasing or decreasing the number of boxes depending on the required structure. Due to the use of timber, the boxes can also easily be CNC-cut and assembled, and therefore be produced in most workshops.

All discrete systems inherently focus on a design language and construction logic that preclude the assembly problem often found in digital designs as outlined by Tibbits[13]. They also emphasize ties to their local context, as well as human-machine collaboration through a rethinking of the position of the virtual-physical interface in architectural production. In order to manifest these aspects, discrete systems developed by AUAR include intuitive software applications for desktop and mobile that enable professional designers and lay people alike to easily model structures (Fig.3). Coupled with Augmented Reality (AR), they assist with the manual assembly of the resulting configuration. Construction could also be feasibly fully automated through the applications' ability to interact with industrial robots for on- or off-site fabrication, though the latter still needs to be developed on a larger scale, as systems such as Block Type A are currently limited to the production of the blocks in terms of robotic assembly (Fig. 4). Independent of the particular workflow however, all discrete systems conceive architectural design not as a producer of static built results, but rather a provider of models for building behaviors and expressions. An important means to facilitate this is the shift of the position of the virtual-physical interface towards the realization phase, rather than its current point of involvement in the management of the final design stage (e.g. Building Information Modelling).

Furthermore, discrete systems apply automation in a manner that provoke and incentivize new directions in the production of housing. As instances of the automation model, their adaptability and reversibility is contextualized in a wider discussion on circular economies and changing ways of living and working. One iteration of Block Type A, ALIS (Automated Living System), for example, proposes the use of small custom-designed robots to reconfigure itself according to the needs of its residents. As an exercise on reducing the time in which a typical housing unit is empty during any given twenty four hour period, and an investigation into how spaces can be adapted to their users instead of making users adapt to them, the project also asks wider questions of what housing can be (Fig. 5).

Our Automated Future

As the recent COVID-19 crisis has highlighted with its abrupt relocation of the office into the home, these questions require urgent responses from the design professions. Between climate and housing crises, architects fundamentally need to rethink their approach to and use of digital technologies in order to create an environment of participation and collaboration grounded in principles of discrete coordination. The automation model as an amplifier of such environments uses technology to incentivize the detachment of the Anthropocene from its Industrial Age structures and concepts of living and working. It argues for a digital paradigm that emphasises communities and the local. As the pandemic has also shown us, global supply chains are

[13] Tibbits, "From Automated to Autonomous Assembly", 8

precariously fragile in moments of crisis. Automation therefore doesn't contend itself with speculative ideas for changed behaviors in the way architecture is produced, but rather realigns our existing technological means to a more equitable, sustainable vision for the future of the built environment and beyond. In doing so, it proposes an opportunity for architects to contribute to the adoption of automation in their own profession, embedding it with social and cultural values, instead of leaving major tech companies to exploit automated technologies for increased control and privatization of public spaces.