Automation and the Discrete

Exploring New Potentials for Streamlining Production in Architectural Design Research

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Abstract

Digitisation has proliferated in architectural education and practice in the last several decades. Highly intricate and complex geometries are possible due to increasing computational power, yet when built require processes that typically are incompatible with existing manufacturing and building practices. In this essay, the studio and research laboratory Automated Architecture (AUAR) argue for the utilisation of 'discrete automation' as an approach for design research that places the translation between experimental work, applied testing and prototyping at its centre.

Over the last few decades, architectural discourse has increasingly emphasized computerization and the adoption of digital design and fabrication tools and technologies. However, the myriad of perspectives on the subject do not necessarily address the common practice of designing architectural projects independent of their realization. Generally speaking, Vitruvius' idea that the drawing is the main architectural communicant of the building exposed in the first book of De Architectura[1] has since, although in different ways, cemented itself within the discipline, removing architects from working directly with the built object of their thought.[2]

Instead, both in the context of practice as well as architectural education, digitization has often resulted in the utilisation of new methods of representation for increasingly complex and intricate geometries, which are time intensive and costly to realize physically - examples of this could include projects such as Zaha Hadid Architects' 2007 four cable car stations, where 850 uniquely moulded, double-curved glass panels had to be produced.[3] [Figure 1] And in a pedagogical setting, virtual-to-physical translations are often limited to scaled models or small 1:1 prototypes, perpetuating the notion that visual representation is the focus of architectural projects while physical translation remains largely enigmatic.[4]

We argue that digital technologies should be operational in uniting the acts of designing and building. As explored in our book *Robotic Building: Architecture in the Age of Automation*, architecture is more than just methods. Automation becomes a mechanism to do this, as it enables the streamlining of production chains, by taking a holistic and scalable approach for thinking about computational design and fabrication.[5]We advocate for an approach that recontextualizes such technologies from presently prominent neoliberal paradigms (e.g. parametricism) to new methodological avenues focused on democratisation and decentralisation of architectural production. In academic work at the Bartlett School of Architecture, UCL, as well as in practice as Automated Architecture (AUAR) Ltd, we investigate and propagate 'discrete' design methodologies with fully digital workflows from virtual conceptualisation to fabrication and assembly using automated technologies. Automation is utilised as a means to enable 'design to build' approaches that can be embedded in a context, while also acting as a framework for prototypical design production. This is inherent to the nature of the academic work of AUAR Labs and becomes tested in the practice-based work of AUAR Ltd.

In the work of AUAR, a brief does not necessarily describe a scenario or site, but rather a platform that allows design scholarship to be activated in built work, fostering strong connections between design and realisation. The platform AUAR is developing is underpinned by in-house developed Apps that construct an ecosystem for how digitally integrated workflows can become vehicles for rethinking contemporary issues using automation, such as the need to find solutions for the global housing crisis, and for flexible spaces empathetic to changing ways of living. Simultaneously, the approach maintains strong ties with ongoing developments in the construction industry, where the adoption of automated technologies is presently pushed by venture capital-funded companies,[6] requiring a response from the design field to contextualize these technologies for more distributed, and thus participatory, practice.

Discrete Automation for an Integrated Design Education

The concept of 'discrete' as we use it means parts that are self-similar, with universal connections. In this way discreteness in architecture is fundamentally based on the principles of digital materials, or the facilitation of reversible assembly of such discrete sets of components.[7] This enables the radical reduction of the number of parts that make up a building.[8] To couple these notions with automation means to take an active role in the appropriation of automated technologies for more distributed, democratic production: putting the parts of buildings into the hands of the local communities who otherwise do not have access to the resources to engage with architectural production that would benefit from these tools being deployed. Since the dawn of the ‘Age of Automation,’[9] automated tools have introduced new workflows and modes of production, yet the AEC industries have so far been slow to take them up. Construction is one of the least digitised industries in the world, second only to hunting.[10] It is our position that architects and construction companies need to act now to adopt these before they are further marginalised by further development of these tools by major tech companies. We do this by developing frameworks for equitable collaboration within local communities and technologies with low-threshold access points, counteracting the tendency of automation to affect those who are disadvantaged already the most.[11]

In the discrete automation, design work ceases to be about modelling traditional building parts (e.g. stairs), instead turning to the configuration of the geometry of the universal (discrete) part that is then aggregated into building assemblies. Such parts can vary in scale but will typically retain one scale across a system [Figures 2]. Underlying the part design workflow is the ambition to generate structures and processes that can be assembled using everyday manual tools, or, in the future, robotically assembled, achieved by iterating through configuration strategies, and can be adapted in relation to architectural syntax, tectonics and structural requirements. Discreteness is also coupled with automation to focus not just on the tools of manufacturing but also on developing easy-to-use software that brings down the threshold of expertise needed to access these technologies. Furthermore, the discrete approach is versatile in that it is applicable on a range of degrees of resolution, materials, and both robotic 3D printing and robotic assembly. As such, the approach becomes accessible for a range of contexts.or example, a discrete system using sheet timber is highly sustainable and can be manufactured anywhere with a CNC machine, eliminating the need for ultra-precision, specialized technology and/or the irreversibility of traditional means of constructing buildings [Figure 3] The emphasis on the distributed and the networked enables a shift from automation as purely a means to achieve cost-effectiveness and instead an investment in the social, architectural and technological infrastructure needed in localised settings that can begin to work against the neoliberalism market. This sits in opposition to the tendency found in automation in architecture to centralise and monopolise both the ownership of technology and the skills needed to utilise these tools for architectural production.

Versatility is inherent to the concept of discrete automation, reflecting in the subversion of wider project workflows: since the part is solved in detail before the architectural ‘whole’ enters the procedural stage, questions of fabrication and assembly logic become the core drivers of any aggregation. Hence, in the context of AUAR’s studio at The Bartlett School of Architecture, UCL, Research Cluster 4 (RC4), a culture is fostered that engages students with critical considerations of their project’s buildability and reusability alongside its capacity to use these attributes to become a counterpoint to exclusionary, unsustainable practices in the production of the built environment. The mobile applications for the emerging discrete systems, designed with cooperative frameworks for ownership of both the application and the discrete system, as part of the academic brief underpin this holistic approach through their focus on making the system usable both for professionals and the wider public alike (Figure 4). Further emphasis is placed on the importance of inclusive, participatory models for the profession through a contextualisation of the Apps within questions of global, societal and economic issues and the reappropriation of digital tools for a democratised practice.

Your Home: For Anyone, Anywhere: A Case Study

Automated Living System (ALIS) by Akhmet Khakimov, Estefania Barrios, Evgenia Krassakopoulou, Joana Correia, Kevin Saey (2019) is one such integrated platform developed out of RC4 that is currently being scaled up to broader adoption beyond the academic context. ALIS is fully aligned with the principles of discrete automation: its universal element is a single block with predefined points allowing for both horizontal and vertical attachment to other blocks, allowing for a range of configurations and unlimited structural variations. This model shares similarities with the modularity common to industrialised production of the 20th century in that there are repetitive units, with a reduced family of building elements, and therefore a shorter production chain. Where ALIS diverges is in the ability for the blocks to be universal in terms of a building’s structure, and for adaptation to occur in context at a finer resolution.. While this is possible at the scale of a unit in modular construction, it is not possible at the scale of the element or part. Modularity also requires units to be assembled together in the same orientations, while discreteness enables parts to be assembled in multiple positions and orientations. ALIS blocks are also made out of timber and reusable, extending their lifecycle and allowing for end-of-life recycling. Using industrial robots, the elements are fully digitally prefabricated from CNC'd sheets [Figure /5]. The blocks are post-tensioned, using a mix of global and discrete (local) tensioning and readily available tools for prefabrication. The assembly of blocks into spatial assemblies can be done in two ways: (1) using simple manual tools, or (2), more speculatively, facilitated by a modular robot capable of pick-and-place of the blocks.

ALIS's physical manifestation is accompanied by its App, a platform in which housing is not something individuals own, but rather a decentralized network in which one has shares and living space can be flexibly adapted to changes in occupant's needs. The project therefore is an instance of what automation could become: a tool for a post-capitalist society footed on principles of a sharing economy. The financial model for ALIS lowers the property accessibility threshold, and the flexibility of the spaces constitutes a change towards a built environment centered around increasing global mobility and new work models such as WFH or digital nomadism, allowing ALIS owners to 'take their home where they go'. Through the sustainable nature of the materials, short supply chains vs long life cycle, the adaptability and the intuitive construction method, we position ALIS as a counterpoint to and critique of the capitalist, neoliberal 'starchitect' agenda.

An initial prototype of ALIS consisting of 60 blocks (20 ft high, 170 square foot) built at The Bartlett School of Architecture for the B-Pro end-of-year showcase in 2019 was assembled using only a Cherry Picker by three student builders familiar with the system in five days [Figure 6]. A further, larger iteration in the London Borough of Hackney using about 258 blocks at 25ft height for 538 sq ft of usable space across two floors will be completed next spring in 14 days In spring of 2020, AUAR built Home-Office using 55 ALIS blocks (10ft height, 324 sq ft) at The Building Centre, London. This project was completed within two days by a team of builders unfamiliar with the ALIS system after a brief half-hour introduction and intermittent assistance from more experienced builders [Figures 7,8]. As these examples show, the systems discrete automation generates can be considered almost 'anyone, anywhere' set ups due to the ubiquitous materials and standard hardware pieces.

AUAR's democratising, participatory approach to designing and building can of course be traced back to pre-digital examples such as, in Europe, the Vienna Settlement Movement and GESIBA of the early 20th century,[12] or Enzo Mari's Autoprogettazione

(1974), [Figure 9] both efforts to empower people to actively shape their surroundings through the provision of systems following simple processes and allowing for individual influence. It is our argument that through a re-discovery of such workflows and values, architects can design projects to enable a pushback against systemic issues such as the financialisation of housing. This in turn can become a fundamental element of an architectural education that sees digital technologies as drivers for more meaningful social and economic work using automation, reinstantiating elements of the project of industrialised modernism within a discrete architectural project, rather than purely as 'problem solvers' driven by focusing primarily on increasing productivity or cutting down on costs.

Automation as a Design Project

The implementation of digital technologies to reunify the acts of designing and building allows this scholarship to argue for a shift in the model of architecture that addresses erudite audiences as Vitruvius established initially with his De Architectura.[13] We propose instead a values-centred approach that conceives architecture out of a central ambition of democratising the practice and counter-acting present neoliberal appropriations of the digital in the discipline. The reappreciation for the act of building in architectural scholarship needs to go hand in hand with a culture of critical awareness of the systemic issues in the contemporary built environment, and the profession's responsibility to steer the adoption of automation in construction in a way that fosters this discourse.

As architects and technologists, we centre the development of low-threshold access points to digital design and fabrication tools. As the construction industry digitises, it is necessary to make tools that can support the creation of new kinds of roles within construction that can link design to building. Design apps like the Combinatorial App [Figure 10], developed by AUAR for use with community members and tradespeople, are a first step in exploring the potential of this kind of design research in practice. Automation is a design project,[14] and architects and educators must design for it.

By re-centering architectural production and education around linking experimental work, prototyping and applied testing both virtually and physically, a window is opened for a more engaged, holistic approach to scholarship; scholarship that demonstrates the ability for the discrete to be agile, contextualised, values-centred and iterative. This focuses the discussion of automation in architecture as an opportunity for wider discussions on shifting the politics and practices of the built environment.

[1] Mario Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography, and Printed Images in the History of Architectural Theory* (Cambridge MA: MIT Press, 2001), 19.

[2] Robin Evans, *Translations from Drawing to Building and Other Essays* (Cambridge MA: MIT Press, 1997), 156.

[3] Martin Spring, "Innsbruck cable car stations: Zaha Hadid lifts the spirits", *Building*, November 23, 2017, https://www.building.co.uk/focus/innsbruck-cable-car-stations-zaha-hadid-lifts-the-spirits/3100491.article

[4] Evans, *Translations from Drawing to Building and Other Essays*, 160.

[5] Mollie Claypool, Gilles Retsin, Manuel Jimenez Garcia and Vicente Soler. *Robotic Building: Architecture in the Age of Automation* (Detail Edition, 2019).

[6] See for example: GCR Staff, "Prefab start-up Katerra to get another $700m from SoftBank", *GCR - Global Construction Review*, January 16, 2019, https://www.globalconstructionreview.com/news/prefab-start-katerra-get-another-700m-softbank/

[7] 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

[8] Gilles Retsin, "Discrete Architecture in the Age of Automation", *Architectural Design: Discrete. Reappraising the Digital in Architecture*, Volume 89, Issue 2 (March/April 2019): 10.

[9] Considered to be in 1947, when Ford founded its 'automation department', see: 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.

[10] Rajat Agarwal, Shankar Chandrasekaran, and Mukund Sridhar, "Imagining construction's digital future", *McKinsey Global Institute*, June 24,2016, https://www.mckinsey.com/business-functions/operations/our-insights/imagining-constructions-digital-future

[11] Ruha Benjamin, *Race After Technology: Abolitionist Tools for the New Jim Code.* (Cambridge: Polity Press, 2019) and Virginia Eubanks, *Automating Inequality - How High-Tech Tools Profile, Police and Punish the Poor* (New York: St. Martin's Press, 2018)

[12] A post-WW1 effort to provide adequate housing to war-afflicted citizens through the provision of 'core houses' for self-building and customizing, see: Werkbundsiedlung Wien

[13] Carpo, *Architecture in the Age of Printing: Orality, Writing, Typography, and Printed Images in the History of Architectural Theory*, 19

[14] Mollie Claypool, Gilles Retsin, Manuel Jimenez Garcia and Vicente Soler. *Robotic Building: Architecture in the Age of Automation* (Detail Edition, 2019).