Automation and the Discrete
Exploring New Potentials for Streamlining Production in Architectural Design Research

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Digitization 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 utilization of ‘discrete automation’ as an approach for design research that places the translation between experimental work, applied testing and prototyping at its center.

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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’s idea that the drawing is the main architectural communicant of the building exposed in the first book of De Architectura has since, although in different ways, cemented itself within the discipline, removing architects from working directly with the built object of their thought.

Instead, both in the context of practice as well as architectural education, digitization has often resulted in the utilization 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 molded, double-curved glass panels had to be produced. 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.

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 to thinking about computational design and fabrication.

We advocate for an approach that recontextualizes such technologies from presently prominent neoliberal paradigms (e.g. parametricism) to new methodological avenues focused on democratization and decentralization 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 conceptualization to fabrication and assembly using automated technologies. Automation is utilized 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 realization. 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, 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. This enables the radical reduction of the number of parts that make up a building. 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,’ 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 digitized industries in the world, second only to hunting. It is our position that architects and construction companies need to act now to adopt these before they are further marginalized by further development of these tools by major tech companies. We do this by developing frameworks for equitable collaboration within local communities and technologies.
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. For 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 as an investment in the social, architectural, and technological infrastructure needed in localized settings that can begin to work against the neoliberalism market. This sits in opposition to the tendency found in automation in architecture to centralize and monopolize both the ownership of technology and the skills needed to utilize 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 low-threshold access points, counteracting the tendency of automation to affect those who are already the most disadvantaged.\(^\text{11}\)

In 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 (Figure 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...
with cooperative frameworks for ownership of both the application and the discrete system, as part of the academic brief. 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 contextualization of the apps within questions of global, societal, and economic issues and the reappraisal of digital tools for a democratized practice.

**Your Home: For Anyone, Anywhere:**

A Case Study

Automated Living System (ALIS) by Akhmet Khakimov, Estefania Barrios, Evgenia Krassakopoulou, Joana Correia, and 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 the industrialized production of the twentieth 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 occupants' 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 and critique of the capitalist, neoliberal 'starchitect' agenda.

An initial prototype of ALIS consisting of 60 blocks (20 ft. high, 170 sq. ft.) 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 25 ft.
height for 538 sq. ft. of usable space across two floors will be completed next spring in fourteen days. In spring of 2020, AUAR built *Home Office* using 55 ALIS blocks (10 ft. 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 and 8). As these examples show, the systems discrete automation generates can be considered almost ‘anyone, anywhere’ setups due to the ubiquitous materials and standard hardware pieces.

AUAR’s democratizing, 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 twentieth century, or Enzo Mari’s Autoprogettazione (1974), both efforts to empower people to actively shape their surroundings through the provision of systems following simple processes and allowing for individual influence (Figure 9). It is our argument that through a rediscovery of such workflows and values, architects can design projects to enable a pushback against
systemic issues such as the financialization 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 industrialized 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*.\(^\text{13}\) We propose instead a values-centered approach that conceives architecture out of a central ambition of democratizing the practice and counteracting present neoliberal appropriations of the digital in the discipline. The reappraisal 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 center the development of low-threshold access points to digital design and fabrication tools. As the construction industry digitizes, 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, 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 (Figure 10). Automation is a design project,\(^\text{14}\) and architects and educators must design for it.

By recentering 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, contextualized, values-centered 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.

**Gilles Retsin** is an architect, educator and thinker working at the intersection of computation, fabrication, and architecture. He studied architecture in Belgium, Chile, and the UK, where he graduated from the Architectural Association. He has designed multiple provocative schemes for residential and cultural projects and built experimental installations at some of the world’s most renowned museums and institutions. Retsin is the director of M.Arch Architectural Design and co-director of Automated Architecture (AUAR) Labs at The Bartlett School of Architecture, UCL.

**Manuel Jimenez Garcia** is an architect specializing in design, computation, and fabrication including additive manufacturing. His work is regularly exhibited in galleries, and he lectures and delivers workshops around digital design and manufacturing in architecture schools internationally. In addition to his work in AUAR, Garcia is co-founder of the robotic manufacturing design brand Nagami, and is the director of M.Sc. Architectural Computation and co-director of Automated Architecture (AUAR) Labs at The Bartlett School of Architecture, UCL.

**Author Biographies**

Mollie Claypool is a theorist with a focus on computation and automation, and its relationship to contemporary building practices. She has written, edited, and consulted on articles and books on these topics, including *Robotic Building: Architecture in the Age of Automation* (Detail Edition, 2019). She studied at Pratt Institute, the Architectural Association and is completing her Ph.D. at The Bartlett School of Architecture, UCL. Claypool coordinates architectural theory in M.Arch Architectural Design at The Bartlett School of Architecture, UCL where she is also co-director of Automated Architecture (AUAR) Labs.

Figure 10. Combinatorial app, an in-house 3D discrete design application for professionals and communities alike. (Image by Automated Architecture/Danae Parissi (A); Automated Architecture (B).)
Clara Jaschke is an architectural designer and researcher specializing in digital tools and technology. She holds a Master in Architecture from the University of Innsbruck as well as a MRes in Architecture & Digital Theory from The Bartlett School of Architecture, UCL., where she is now a teaching fellow in addition to being a researcher at AUAR.

Kevin Saey is an architect and researcher in automation, digital fabrication, and computational design with a background in game design. Saey studied Digital Arts and Entertainment at University College West Flanders, and holds an M.Sc.i in Architecture from KU Leuven and an M.Arch from The Bartlett School of Architecture, UCL.

Notes
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