Our Automated Future: A Discrete Framework for the Production of Housing

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What are the social, economic and political consequences of a shift towards full automation for the production of architecture – and, specifically, housing? It is a question that an experimental studio within the Design Computation Lab at the Bartlett School of Architecture, University College London has been exploring for several years. The lab's co-director Mollie Claypool discusses the philosophical, theoretical and design background against which their investigations have been carried out, and presents some of the housing fabrication projects that they have produced.

In a world plagued by a housing crisis where millions live without adequate shelter, how can a fully automated production chain for architecture enable us to produce more quickly, more efficiently and with highly reduced costs, housing that can respond to changes in family structures, in the way we organise our communities, and in how we relate to our physical and virtual environments? How can the automation of the built environment enable us to rethink the way in which we incorporate these technologies and new social and economic frameworks into architectural design and construction practices that engage with wider communities that include architects and contractors, but also users/inhabitants, policymakers and/or other stakeholders? How does this social awareness affect historical and cultural understandings of the meaning and value of what the Discrete holds for architecture? These are some of the questions which have been the catalyst for a body of work produced over the last four years in Unit 19, an experimental architectural design studio that is part of the Design Computation Lab (DCL) at the Bartlett School of Architecture, University College London that develops Discrete, automated frameworks for the production of housing.

There are several paradigms that Unit 19's work has contextualised itself against, within and/or in reaction to, as a means of projecting potential possibilities for the future of architectural design and construction. The work draws on the writings of contemporary philosophers and theorists, and notably on technological left-accelerationism as expounded by Nick Srnicek, Alex Williams, Benjamin Bratton and the collective Laboria Cuboniks. Contextualising the work alongside manifestos such as Laboria Cuboniks' 'Xenofeminism: A Politics for Alienation' (2015), Unit 19 believes in the need to 'strategically deploy existing technologies to re-engineer the world'.[1] This is not an impossible challenge, nor is it 'a free-floating project, since [the] frameworks […] already exist and have traction in the world'.[2] It requires an assessment of, engagement with, and disruption of the economic, social and political issues that currently restrain societal shifts towards Discrete design and full automation, whether these are political, economic or cultural, or are stereotypes or discriminatory practices.

Finally, We Are Digital

Architecture is a profoundly material discipline that must acknowledge whom it is supposed to serve in more meaningful and valuable ways. To work with a Discrete model is therefore to be against neoliberalism, monopolisation, centralisation, customisation, localism, consumerism, the analogue, non-scalability, and highly Discrete and laborious design production (some being qualities of 'folk politics').[3] By promoting systemic thinking, universal and flexible frameworks, economies of scale, platforms, open-source, decentralisation, the prototypical, mobility, prosumerism, the digital, scalability, and continuity in design production, we can propose an 'all digital' or 'wholly digital' Discrete approach to the automation of housing production.

As Srnicek explains further in *Platform Capitalism* (2016), 'in order to understand our contemporary situation, it is necessary to see how it links with what preceded it. Phenomena that appear to be radical novelties may, in historical light, reveal themselves to be simple continuities.'[4] A new generation of designers are now questioning the lack of social value and impact of the work of previous generations of the digital which was ultimately unable to translate into architecture and which holds real positive value for, and of, the wider public. That work, using Srnicek's terms, therefore constitutes 'simple continuities'. This is aligned with the argument towards the discretisation of the spline that the architectural historian Mario Carpo argued for in his essay 'Breaking the Curve' in *Artforum* in 2014.[5] It draws on work on digital materials by Nick Gershenfeld at Massachusetts Institute of Technology (MIT) who defined a digital material as being 'assembled from a discrete set of parts, reversibly joined in a discrete set of relative positions and orientations'.[6] Digital materials by their very nature are able to transcend scales and platforms due to their (geometric, structural, material) abstraction and therefore can be more inclusive and equitable as a framework for design.

An all-digital Discrete approach has roots in 20th-century architecture, particularly in the work of Jean Prouvé (Maison Tropicale, 1949–52), Buckminster Fuller (exemplified by his book *Nine Chains to the Moon*, 1938) and Frei Otto (notably the Munich Olympic Stadium, 1972) who developed entire production chains for their projects (amongst others surely also recognised elsewhere in this issue of *AD*). However, these architects were still limited by the modernist paradigm for architectural syntax – ie column, beam, floor slab, stair etc (although Fuller made some progress in disrupting this with the Dymaxion House (1930), as did Otto). When we move away from building elements being specific to their architectural function and towards an architecture made of a discrete set of parts, then we begin to move into the wholly digital paradigm, thinking of building blocks as open-ended, scalable, universal and versatile. Contemporary projects such as WikiHouse (2011–) or the work by ENSAMBLE Studio such as Cyclopean House (2014–16) are attempts to pursue aspects of a wholly digital project. WikiHouse still exists within earlier digital paradigms because it is a highly bespoke and customised model for the production of housing. Similarly, the Cyclopean House has a high degree of even though it utilises distributed manufacturing and is made of a discrete kit of parts.

Prosumerist Co-production

Today's smart gadgets and devices that emphasise an individualised and real-time fully customisable experience of the built environment are ubiquitous. This paradigm of the individual is ignorant of the meaning and value that that individual could add to the process of producing their physical environment: it is merely the customisation of a standard. The ‘end-user’ has a limited amount of perceived value in this kind of economic model. Unit 19/DCL is against privileging the notion of the ‘end-user’ as well as customisation for the sake of a ‘personalised’ architecture, and is for the integration of the ‘user’ at all stages of design, fabrication, assembly and inhabitation of architecture. Unit 19 projects recognise that the way in which many digital technologies have been used succumb to the constraints and protocols determined by systems of power and centralised networks of capital and capitalist production.

By advocating a participatory, co-produced framework for housing, the concept of ‘prosumption’ or the ‘prosumer’ rather than consumption and the consumer can be engaged with. This enables prosumer(s) – embedded at each stage of the design, fabrication and assembly process, and over the course of the period of ownership of the house – to increase the value of their own impact into the architectural system by embedding their knowledge into our systems of production. The work of Ivo Tedbury (2017), notably his Unit 19 project *semblr*, explored developing open-source software such as web- or desktop-based apps that enable non-specialised users (the ‘layman’) to access design tools in order to use them to specify their needs and test different outcomes, using economic, physical (eg site-based) and/or social constraints to do so. Users can specify how many parts they need according to their current needs, taking into account any possible predictions for required adaptations over time to changing financial or social circumstances.

Figure 5.tiff
Figure 6.tiff
Figure 7.tiff
Figure 8.tiff

Automated Redistribution

Fully automated technologies can also aid in the predicting of how the system may cope with or anticipate changes in the future, as well as reducing the amount of human labour (and therefore a degree of overall cost of design and construction). Autonomous robots can be used to assemble, disassemble and reassemble houses entirely, picking up parts and distributing them where required, as in Ivo Tedbury’s project *semblr* (2017). These techniques require substantially less human labour than is typical of traditional construction or assembly of housing, enabling a redistribution of resources across society.

On a larger scale, by designing into the framework a chance for wider community-led engagement with the geometric (structural, spatial, material), economic and social rules of the part-to-whole relationships that are built into discrete kits of parts, communities at whatever scale can inform the way that the social, political or economic models of the whole (eg the architectural outcomes). More traditional construction materials such as precast concrete can be utilised alongside discrete kits of vacuum-formed moulds that allow for relatively quick, repetitive fabrication of parts, such as in Oscar Walheim’s project *Avila Automatic* (2017). Lightweight materials such as foam (sprayed with fibre-reinforced concrete), as in Julia Baltsavia’s project *i-Architecture* (2017), or oriented strand board (OSB) as in Alessandro Conning-Rowland’s project

Chamfer: A Cooperative Housing Platform (2018), can be used and designed to be fabricated for the least amount of waste possible and forego the use of heavy machinery in assembly.

Figure 1 (1)_edited-1.jpeg
Figure 3.tiff
Figure 2.jpg

If parts individually act as one half of a mould for in-situ concrete casting, a community can uses the set of expanded-polystyrene (EPS) moulds to design and negotiate spatial configurations over time with varying degrees of privacy and temporality, making areas of the housing permanent by casting when required and negotiated by the community, as in Ossama Elkholy's project *Cooperative Casting* (2018).

Figure 4.tiff

The redistribution of resources through a Discrete model enables inclusivity, distributing knowledge (both specialist and non-specialist) throughout the project, providing for more equitable and democratic production of housing. The design question for architects therefore shifts from how buildings respond to a social or physical context through their appearance or presence, to how they are produced, and thus embody particular cultural conditions, including economic, political or social values. In this, the role of the architect shifts towards that of a designer of a system, where the architect manages a conceptual and methodological framework for architectural production. Importantly, it also enables users to not be passive receivers of knowledge via specialists, but active participants in informing how automated technologies are used and the shifts in conceptions of value and social practices that they might produce. Otherwise, what are we (you, architect) doing this for?

Towards Discrete Continuity

Advanced digital fabrication and manufacturing technologies such as industrial robots and 3D printers are commonly used in construction either as replacements for human labour (mimicking actions of the human body) or on the other end of the spectrum, as representational devices: to make copies/replicas of existing building elements. Recent examples include SAM the robotic bricklayer by Construction Robotics, and Winsun's 3D-printed houses or 3D-printed wall panels. Buildings realised by the architects of the first digital turn were/are often hugely over-budget and inefficient, as the basic building blocks for architecture are still planned and put together through processes that are very much reliant on techniques developed in the 19th century with the advent of the Industrial Revolution – for example, a very slow, laborious and highly Discrete production framework. In addition, the legal system has only now just begun to catch up with a system where parties are simultaneously an author and owner of a design.

Utilising smart contracts and blockchain, we can speculate on a near-now in housing production that disrupts this dichotomy where design and construction are held in opposition (whether due to financial, political, legal or socio-cultural issues). Ownership can be incremental and capital transparent. Overly specific building elements, as in conventional design where every piece is designed and fabricated with high degrees of specificity and low tolerance, have no place in this kind of model. Instead, through the Discrete, building blocks are part of a feedback loop between design and fabrication. Building blocks can be distributed with an exactness to the virtual model, with high tolerances due to use of robotics to programme both fabrication and assembly behaviours. This is closely aligned to Gershenfeld's recognition that while fabrication technologies are embedded with digital logics, materials were analogue.[7] In a wholly digital model for the production of housing, there is almost no difference in architectural syntax between design, fabrication or assembly. Furthermore, this kind of platform can be coordinated to cross-scale in terms of systems of material to labour, from material manufacturing to post-occupation and from analogue labour to automated labour. A model for Discrete continuity facilitates our inevitable future of full automation.

Notes

1. Laboria Cuboniks, 'Xenofeminsm: A Politics for Alienation', 2015, www.laboriacuboniks.net/#zero/3.
2. Nick Srnicek and Alex Williams, *Inventing the Future: Postcapitalism and a World Without Work*, Verso (London), 2015, p 107.
3. *Ibid*, pp 9–13.
4. Nick Srnicek, *Platform Capitalism*, Polity Press (London), 2016, p 9.
5. Mario Carpo, 'Breaking the Curve: Big Data and Design', *Artforum*, February 2014, www.artforum.com/print/201402/breaking-the-curve-big-data-and-design-45013.
6. Neil Gershenfeld, Matthew Carney, Benjamin Jenett, Sam Calisch and Spencer Wilson, 'Macrofabrication with Digital Materials: Robotic Assembly', in Achim Menges (ed), *AD Material Synthesis: Fusing the Physical and Computational*, September/October (no 5), 2015, p 123.
7. *Ibid*, pp 122–7.

CAPTIONS

Group with three images below (shared caption label):

Figure 5.tiff

Ivo Tedbury, / Design Computation Lab (DCL) Unit 19, *semblr*, Bartlett School of Architecture, University College London, 2017

As in many Unit 19 projects, *semblr* proposes an online platform where users can test potential building outcomes utilising specific constraints such as financial, familial, contextual or other requirements which are constrained against structural, material and geometric possibilities of the kit of parts.

Figure 6.tiff

The system's technical foundation is a single syntax for cross-disciplinary coordination between the building elements (and their geometry), and the robot's end effector (tested here with an industrial robot).

Figure 7.tiff
In *semblr*, discrete timber building blocks and distributed robots that move relative to the structure that they assemble make up the building assembly process.

Figure 8.tiff
This platform enables outcomes to be tested for changes that may be required over time, allowing users to expand or contract their home as required, making it more or less permanent depending on lifestyle or other constraints.

Figure 1 (1)_edited-1.jpeg
Oscar Walheim / DCL Unit 19, *Avila Automatic*, Bartlett School of Architecture, University College London, 2017
Avila Automatic explores a self-replicating, recombinant architecture through the deployment of vacuum forming on computer-numerically controlled (CNC) moulds that generate precast concrete building elements. The discrete and digital formwork facilitates the exploration of a new kind of construction framework that has scalability engrained into the system from the outset.

Figure 3.tiff
Julia Baltsavia / DCL Unit 19, *i-Architecture*, Bartlett School of Architecture, University College London, 2017
i-Architecture proposes an open-source system based on a kit of parts that can be fabricated using robotic hot-wire cutting, allowing for rapid and efficient deployment of an open-ended and adaptive housing project. The discreteness of the parts allows for scalability from the minute stair detail to overall structural organisation.

Figure 2.jpg
Alessandro Conning-Rowland / DCL Unit 19, *Chamfer: A Cooperative Housing Platform*, Bartlett School of Architecture, University College London, 2018
Chamfer enables resident-initiated, funded, democratically designed and self-constructed housing, made possible through shared living, shared knowledge and the combinatorial possibilities of building element chunks. The geometry of these chunks promotes desired spatial and social outcomes, whilst physically they embrace low-cost materials such as OSB and cardboard and highly accessible fabrication technologies such as CNC milling.

Figure 4.tiff
Ossama Elkholy / DCL Unit 19, *Cooperative Casting*, Bartlett School of Architecture, University College London, 2018
In *Cooperative Casting*, a discrete kit of ½ EPS moulds that can attach to one another are used to assist in a quick initial deployment and occupation of the sites, enabling users to negotiate living space with their neighbour by rotating the combined uncast pieces. Casting

the moulds adds permanence to the user's dwellings, but more importantly becomes used as a negotiation tool for further adaptation, expansion or evolution of the building as a whole.