Discrete and Digital: A Discrete Paradigm for Design and Production

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THE SLAB

For the 2014 Venice Biennale, Rem Koolhaas suspended a typical office floor slab under the gold pleated neo-classical cupola of the Italian Pavilion. A thin, plasterboard surface covered a thick, volumetric layer of HVAC tubes, cables, switches, and sensors. This installation created a moment for architecture, not unlike the moment where Neo wakes up from the Matrix, after taking the red pill. The dome, and its contemporary equivalent of the plasterboard surface, is the known world, normal, safe, controllable—a blur of brick, plaster, paint, and goldleaf. This is the world Neo inhabits in the simulation set up by the Matrix. The world behind that, however, is a managerial world of ruthless logistics and cold precision. Far deeper and darker than the surface-thin plasterboard world, it is also a domain without architects—governed by other professions, sub-professions, consultants, and corporations with global reach. The slab revealed what is left to the architect: the plaster surface below this ceiling, punctured with ventilation exhausts and fire escape signs. Koolhaas's slab invites the architects to make a choice. You could settle for the surface, decorate it, and upload it with texture. Or you could take a risk, resist, and go for the volume, the structure behind it. The last option will take you to the foundations; the first one will only let you scratch the surface. Engaging with the world beyond the surface gives architects access to what Marx defines as the "mode of the production"—the system of production and distribution—with all of its social and political consequences. At the same time, questioning the "volumetric package" also gives access to questions of architectural syntax—the system of part-to-whole relations, or "mereology" of our built environment. This paper is an invitation to leave the surface behind and recolonize the depth of architecture, fundamentally questioning how it is produced, distributed, and given form. It's also an invitation to think about syntax, about part-to-whole relations, as a way to access another discussion about modes of production. This discussion cannot avoid "the digital"—both as an intellectual challenge to make sense of the single biggest force of change in our world, and as a pragmatic realization that production in general has become digital.

WE HAVE NEVER BEEN DIGITAL

In "Breaking The Curve," Mario Carpo describes the inherently discrete nature of computational processes, opposing it to the continuous logic of pre-computational, modern science (Carpo 2014). Carpo describes how the 1990s generation of digital designers, or "Spline Makers," are using essentially old differential mathematics, and modern concepts such as geometry and topology. The following generation, as identified by Carpo, uses the discrete logics of computation—which he then relates to a new kind of science based on computational power. Building upon this distinction between the continuous and the discrete, this paper argues that perhaps *we have never been digital*.[1] Hinting at Nicholas Negroponte's "Being Digital" (Negroponte 1995) and Bruno Latour's "We Have Never Been Modern" (Latour 1991), this provocation argues that architects have fundamentally misunderstood not only the nature of the digital, but also its economy and social implication. By arguing that *we have never been digital*, this paper is critical of both what is considered "digital" in architecture and, consequently, what is considered "post-digital."[2] Per definition, we cannot be post-digital *yet*, when we have not been digital in the first place.

Figure 1: Softkill Protohouse (2012), Prototype for a 3D printed house, 2011–2012 AA-Design Research Lab thesis project. In collaboration with Sophia Tang, Nicholette Chan, and Aaron Silver. Critics: Robert Stuart-Smith, Knut Brunier, and Tyson Hosmer.

The work identified by Carpo as the Second Digital Age[3] is only discrete to a certain extent. From the point of view of production, the work, in fact, still relies on continuous fabrication techniques. The notion of discreteness only exists in the design process. To realize the resulting complex geometries, the architects have to rely on the same fabrication techniques as the previous generation: mass-customizing segments, through either CNC-milling, robotic fabrication, or 3D printing. For example, if a robot is used to carve a medieval sculpture out of a large block of stone, it is actually computerizing a process that is merely analog. This harsh distinction between digital and analog fabrication is convincingly argued for by Neil Gershenfeld (Gershenfeld 2015). In order to be considered digital, a fabrication process has to operate on a material that is itself digital.[4] Essentially, Mario Carpo's distinction between discrete and continuous not only exists in the digital world, but also in the physical world. Digital data is based on discrete units with limited connection possibilities, or whole numbers, whereas the continuous is based on infinite numbers. The core of computation is the use of one universal element, which can have two distinct values: 0 or 1. This binary unit, or bit, then becomes a versatile building block with which to compute. In this sense, we can also think of physical, material organizations as being digital or analog. If all the elements in an organization are discrete, serialized, and relational elements with a limited connection possibility, then it can defined as a digital organization. In this case, it's interesting to note that Gramazio Kohler's Programmed Wall, made of robotically assembled, discrete bricks, is not digital but analog, as the brick has a vast amount of connection possibilities. It's indeed continuously differentiated. A LEGO wall, on the other hand, could be considered digital, as the male-female connections are limited.

Continuing this logic, Carpo's "Second Digital Age" does not operate with material that is digital. In fact, there is no notion of discreteness here; there is no unit, or bit, in the digital process which corresponds to a unit in the production process. There is no relation between the fabrication process and the design process—once finished, the resultant form has to be sliced up and rationalized in fabricatable data. This discrepancy between design and fabrication results in a representational gap between the two processes. These findings lead to the argument that fundamentally, the whole process is still to be considered continuous, rather than discrete, and therefore also analog, rather than digital. Later on, we will also expand this argument from the point of view of production.

This discussion about discreteness can also be continued in relation to syntax, the system of part-to-whole relations, or mereology, of an architecture.[5] In *The Mathematics of the Ideal Villa*, Colin Rowe compares the underlying geometric order of Le Corbusier's Villa Stein to Palladio's Villa Malcontenta, arguing that both are based on classical composition (Rowe 1947). He then concludes that modernism was actually not modern. In his essay "Post-Functionalism," Eisenman further dismantles modern architecture based on a criticism of form-follows-function, and argues for an architectural syntax that is truly modern—in the same way that the atonal composition of Schoenberg and Webern is different from classical music (Eisenman 1976). The argument that *we have never been digital* can therefore also be looked at from this more formal and architectural perspective. This paper argues that until now, architects have only produced buildings with an analog syntax. The experiments from the 1990s are still based on surfaces, on geometry, sliced in continuously differentiated segments. Their physical material organization is analog, as is the designed syntax.

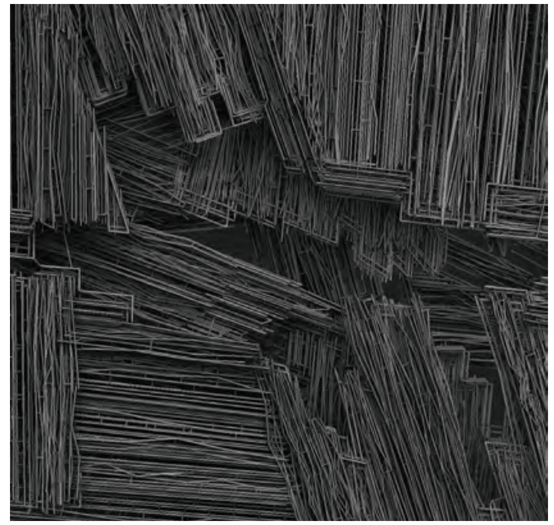


Figure 2: Budapest New National Gallery, Gilles Retsin Architecture with Lei Zheng (2014)

Figure 3: Guggenheim Helsinki, Gilles Retsin Architecture (2014)

DIGITAL PRODUCTION

It could be argued that the architects' misunderstanding of the nature of the digital finds its origin in digital production. Since the 1990s obsession with the CNC machine, digital manufacturing machines have been mainly understood as devices that allow the building of thousands of self-similar but different variations at the same cost as an identical copy (Carpo 2011). This idea of variation and differentiation formed a powerful argument, opposed to the Fordist assembly line based on serial repetition (Lynn 1999). Already in this argument, there is a misunderstanding about the economy of digital production. The CNC-machine, for example, was initially developed for its repeated precision, not for its capability to produce difference (Noble 1984). Similarly, an industrial robot arm offers the capability for precision and repetition. The architects' discourse of difference was framed in a context of "mass-customization," an economic buzzword that was popular in the 90s, but which has since faded to the background of the discussion.[6] It has been replaced by new concepts such as the Sharing Economy, Internet of Things, Big Data, and the Platform. In fact, the architects of the 90s also misunderstood the logic of mass-customization itself as a form of formal differentiation, while it was actually thought of as an improvement in production chains. Today, the only commercially available item that is slightly customized along the lines of what the architects imagined is the NIKEiD shoe, which allows customers to choose a few different colors and textiles. The vast majority of other products are still standardized, and, in fact, have become ever more standardized. For example, the majority of the world now uses only one or two types of cellphones—a situation not incomparable to the Ford T. There is of course no need to customize the actual form or shape of your smart phone—why would you? What is customized is the content, the software, the apps you install. The real premise of digital production is not its ability to formally differentiate parts, but rather its potential to cut production chains short and to distribute manufacturing. As Jeremy Rifkin describes, with digital production, basically any type of product could be produced without involving a whole array of machines, factories, subcontractors, suppliers, etc. Quick variations or iterations of these products can be produced without any additional cost (Rifkin 2014). However, it's important to realize that, in fact, this is not about the idea of being able to produce lots of formally different products (for example, everyone having his own iPhone design—for that there are iPhone covers). The most seminal products of our digital age are designed as simple, rigid platonic solids: the iPhone, Alexa, MacBooks, or WiFi routers. The actual potential of digital technologies is not the differentiation of shape, but the fact that you would be able to manufacture an iPhone anywhere in

Figure 4: Guggenheim Helsinki, Gilles Retsin Architecture (2014)

the world, without a massive production chain, and that you would be able to iteratively and quickly improve the design. In the context of architecture, Jose Sanchez has advanced this argument to argue for 3D-printed building blocks called "Polyominoes" (Sanchez 2016). This idea links back to the aspect of mass-customization that has appealed most to businesses and is here to stay: made or built to order. An object is only manufactured at the moment someone has purchased it. However, this aspect of "made to order" again relies on another form of the Fordist assembly line that was dismissed by the architects of the 1990s: universal modular components. These modular building blocks, used for hardware and electronics, are much more akin to Neil Gerschenfeld's idea of Digital Materials than to architects' dreams of "formally differentiated" parts. Through focusing on formal differentiation, the architects of the continuous paradigm have wildly misunderstood the idea of production in the digital age. Just as Rem Koolhaas's suspended slab, digital production and mass-customization are about the cold logics of extreme management and precision, relying on ideas of assembly, modularity, and universality.

BEING DIGITAL

The architectural model closest to Rifkin's idea of digital production is probably the WikiHouse: a platform for an open-source house that can be produced out of small-scale elements manufactured on cheap, self-built CNC machines, which themselves are also open-source. We see all the characteristics of a digital economy here: the idea of a Wikipedia-like platform that brings together free information, distributed manufacturing, short production chains, and the ability to iterate. Of course, every WikiHouse can be slightly different, customized to the family and site, but fundamentally, it has nothing to do with formal differentiation itself. The WikiHouse is in this sense more "digital" than any parametric design or 1990s surface project. This is altogether a very different understanding of digital production compared to the mass-customized Nike shoe. Moreover, it has a political implications: the agency for production and design, the platform, can be owned by people or cooperatives rather than large companies.[7] The WikiHouse is a clear example of how production can be democratized. It's this type of digital economy that forms the basis for what Paul Mason calls postcapitalism, the moment when freely available information products disrupt the artificial scarcity of the market (Mason 2015).

However, in the context of our previous discussion about digital syntax, the WikiHouse is syntactically still analog. It's digital in its economy, but not in its syntax. Ironically, the WikiHouse is based on a parametric and continuous understanding of part-to-whole relations. First, a global form is defined, which is then sliced into thousands of different elements. A large amount of waste occurs, as the parts do not correspond to the sheets they are cut from. Moreover, the large amount of different parts results in a complicated assembly process, and opens up more space for errors to occur.

This paper will further expand a proposal for an architecture that is digital in its design, production, syntax, and economy. Essentially, a fully digital architecture would establish a new type of non-analog syntax, one based on a set of versatile and recombinable bits or parts that can be manufactured and shared through a Wiki-like platform of production. This digital syntax, per definition, rids itself of geometry and becomes purely based on relations. In the attempt of "being digital," architecture inevitably escapes the surface and again gains access to discussions about modes of production, which allows the discourse to take part in a larger discussion about the social and political consequences of the digital.

TOWARD A DISCRETE SYNTAX

In *Animate Form*, Greg Lynn advances an influential argument for a new type of architecture closely associated to a new idea of design and production. A series of NURBS curves, perhaps the most seminal diagrams of the digital, explain how architects now are no longer engaged in assembly but have access to continuous differentiation of matter. Using Tafuri, Lynn compares the modernist curve to the assembly line and then situates his curve in a new domain of production and differential calculus. However, as Daniel Köhler points out, Lynn's understanding of the curve already implies the loft, which in itself again introduces a form of repetition (Köhler 2016). Moreover, this lofted surface immediately also implies a mode of production: segmentation. Most iconically, this segmentation method was later applied to construct the Yokohama Port Terminal by FOA. An initially continuous surface is defined and then laterally sliced into a multitude of different segments. A whole generation of computational research in architecture has done exactly that: defining an overarching form, shaped in a field of forces, and then rationalizing it in a series of differentiated segments. The argument behind this "mereological nihilism"[8] is that digital fabrication tools afford us this degree of difference. Continuing the critique of the lofted surface, with its absence of parts, Köhler then reproduces Lynn's curve as an assembly of line segments, conceived as physical bodies, hinged together (Köhler 2016). This compelling diagram literally "breaks the curve"—as in Mario Carpo's text. Inspired by Köhler's provocation, this paper will attempt to break some more curves, doing this by illustrating a series of projects using the same NURBS curve as a syntactical diagram. The projects, by Gilles Retsin Architecture, are organized in three parts toward a digital syntax: starting from the continuous, to the discrete-but-not-yet-digital, to the digital.

1 The Ultimate Continuous

The first step in our syntactical journey starts with the Softkill Protohouse (fig. 1), a project developed at the AA-Design Research Lab in 2012. The Protohouse is a prototype for a 3D-printed house, speculating on the existence of a fictional 3D printer that can print large blocks of material on a very high resolution and with sufficient material strength. The project is not based on a geometrical understanding of space: it starts with a large, voxelized volume that contains data from a stress analysis. Every voxel in this space contains data about deflection, maximum force, tension, and compression, as well as vector information, such as the direction of stress flow. Subsequently, this space is randomly populated with agents[9] that maneuver through the vector field, leaving a trace behind. These traces then combine with each other, bundling into a fibrous mass of material. The Protohouse is a first, important step in moving away from surface, geometry, and topology. The algorithmic process produces an organization of material that is completely volumetric, and fundamentally different from Lynn's lofted surfaces or earlier agent-based projects that maneuvered over surfaces.[10] Greg Lynn's NURBS curve diagram therefore becomes a continuously differentiated mass of lines. This approach is an important precedent for the discrete, as it establishes a volumetric syntax. Based on a fictional large-scale 3D printer, there

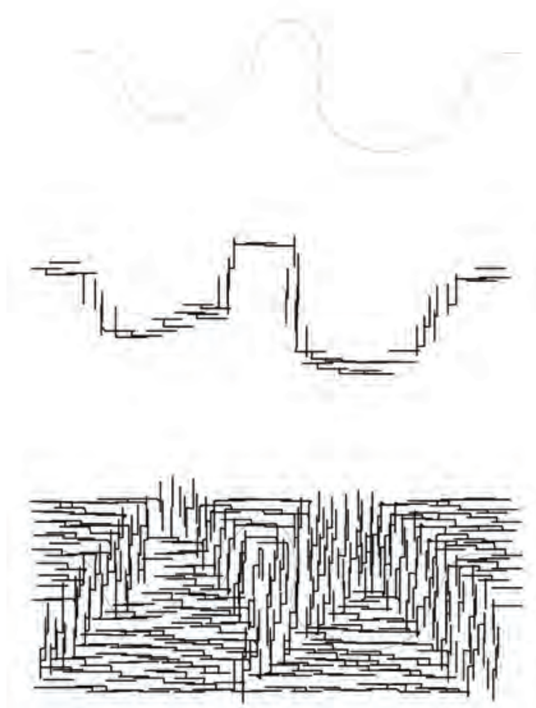


Figure 5: Discretizing Greg Lynn's NURBS curve, Gilles Retsin (2016)

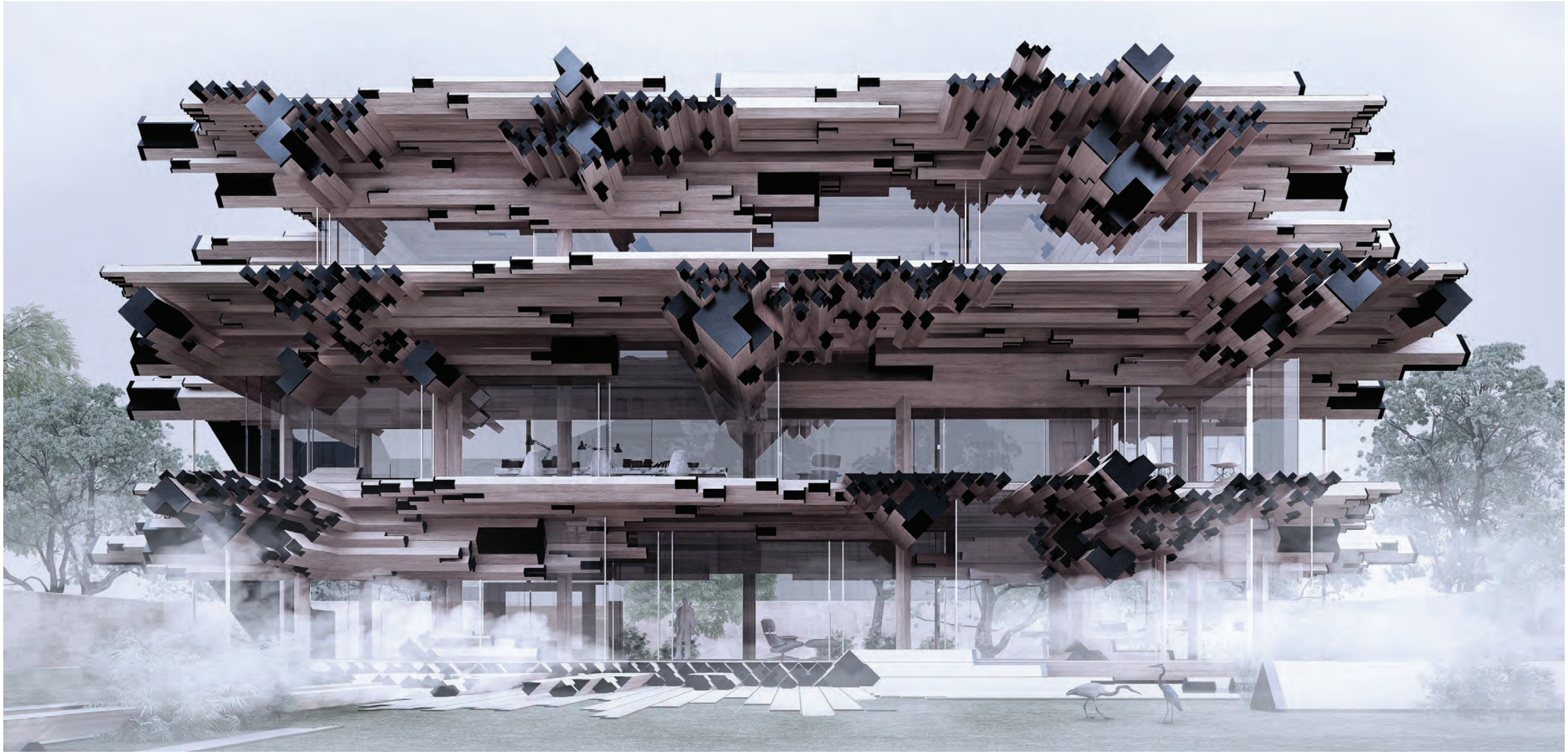
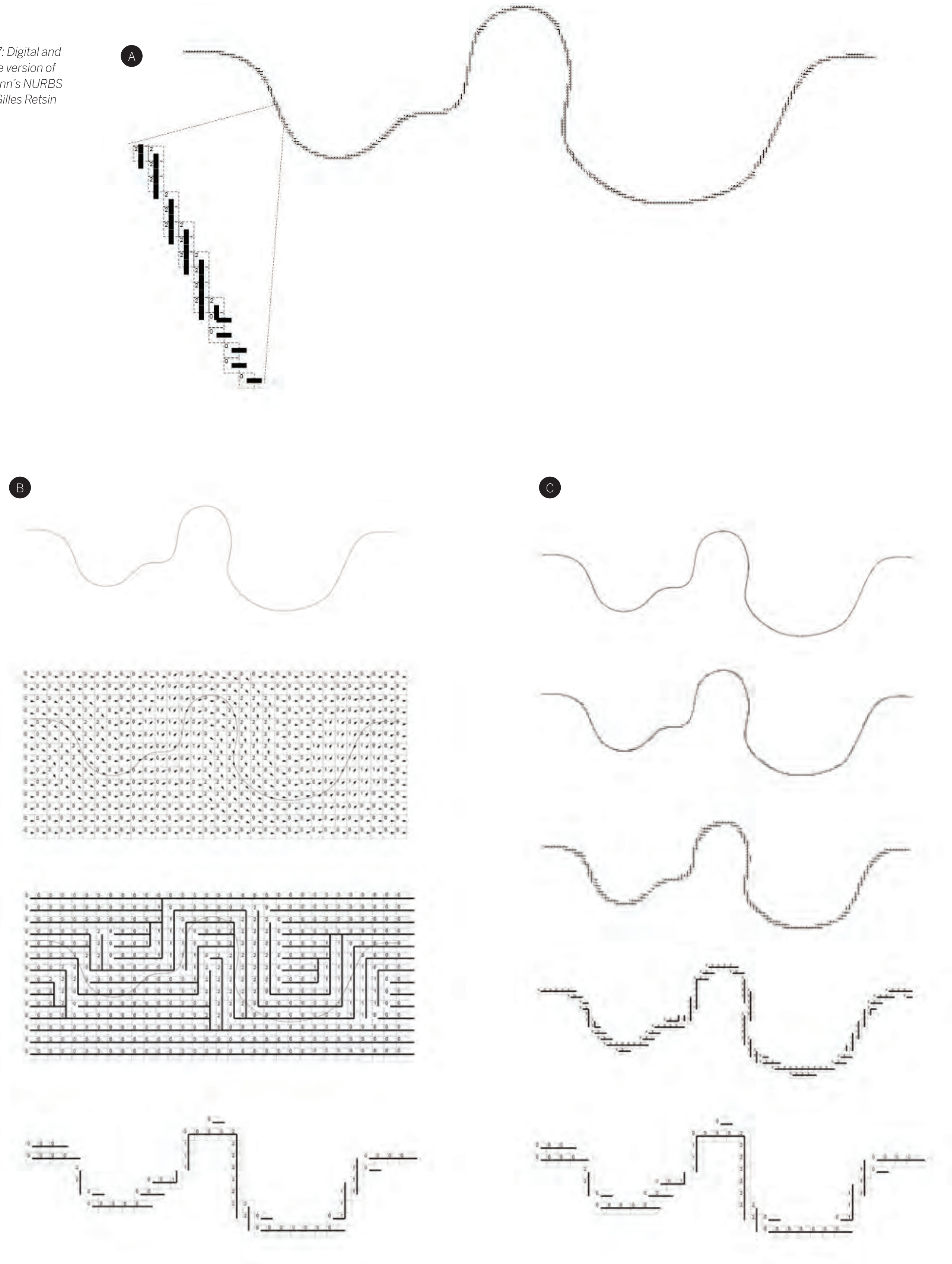


Figure 6: Diamond House, Wemmel, Belgium, Gilles Retsin Architecture (2016)

Figure 7: Digital and Discrete version of Greg Lynn's NURBS curve, Gilles Retsin (2016)



is, however, no notion of a parthood or assembly, just a continuous distribution of material. In fact, the project can be understood as the *ultimate continuity*, not only continuous in the UV-space of a surface, but also in a volumetric way. So, despite the non-geometric qualities of the project, the Protohouse should still be considered a continuous and analog syntax.

2 The Discrete

In a further step toward discreteness, the amount of entropy in the system is reduced, and an initial approach to parthood, serial repetition, and assembly is introduced. Rather than supposing a large, notional 3D printer, the subsequent development looks at the assembly of line segments into a large whole. The elements don't have a predefined connection; they can be connected in multiple ways. In that sense, the connection is not serialized, and there is still a considerable amount of customization and tolerance in the system. The competition for the Budapest National Gallery (2014) (fig. 2) and the Helsinki Guggenheim (2014) (figs. 3 and 4) reflect this approach. Both projects are based on a serial repetition of discrete "sticks," or linear timber struts. This kind of material organization is discrete, but given the high amount of tolerance in the connections, it is also still analog. These "stick projects" are fundamentally different from Greg Lynn's, as they are not based on surface, topology, and geometry, but on volume. Lynn's curve diagram becomes a volumetric assembly of sticks (fig. 5). This approach is also different from the Protohouse, as there is a notion of parts, assembly, and serial repetition. At the same time, they resonate with the volumetric and fibrous organization of the Protohouse. In conclusion: sticks are discrete, but not yet digital. Both stick projects start to dissolve defined wholes, introducing a porous assembly based on parts. Although diagrammatically organized as a series of slabs, the argument for the Budapest National Gallery is that there are in fact no slabs active as objects in the composition. There are only parts, and relations between the parts.

It's interesting to note here that this kind of approach relates more to Stan Allan's "field conditions" than to Greg Lynn's writing. Essentially Allan's field conditions are based on serial repetition and the dissolution of the figure. Figures are composed out of the interaction and relation of a multitude of elements. This idea already goes beyond geometry and topology. Moreover, the field conditions proposed by Allen are also open-ended, and not part of a formal style; they could, for example, be both curved or straight. Allan's field conditions already imply an aesthetic and ethical world that is very different from Lynn's and the later proto-parametric approaches. It flirts with minimalist artists like Sol Lewitt and Donald Judd, who, of course, have an inherent link to the syntactical and systemic. It also identifies some of the core buildings of late-modernism as field conditions, such as Le Corbusier's Venice Hospital and, indirectly, projects such as van Eyck's Orphanage. In doing so, it creates a historical link between new, computational approaches and late-modernism. We'll speculate more about this further along in this paper, but essentially, one could draft an alternative history of precedents for the digital, bypassing Antoni Gaudí, Frei Otto, and Greg Lynn. This lineage would then run over early computational experiments by people like Paul Coates and the structuralist architecture of van Eyck and Hertzberger, to the serialized production of Jean Prouvé, the minimalist art by Sol Lewitt, Stan Allan's field conditions, and then, effectively, the discrete and the digital as outlined further below.

3 Discrete and Digital

The next iteration of work advances and prototypes a digital syntax, based on serially repeated building blocks with a digital connection logic, similar to Neil Gerschenfeld's Digital Materials. As explained before, these building blocks act the same way as digital data, which means that they can be recombined and are reversible, universal, and versatile. The first important precedents of this approach is EZCT's Universal House project (Morel 2011), which proposes a physical building block that can be assembled into multiple different buildings. With a kind of dark humor, the building block itself is

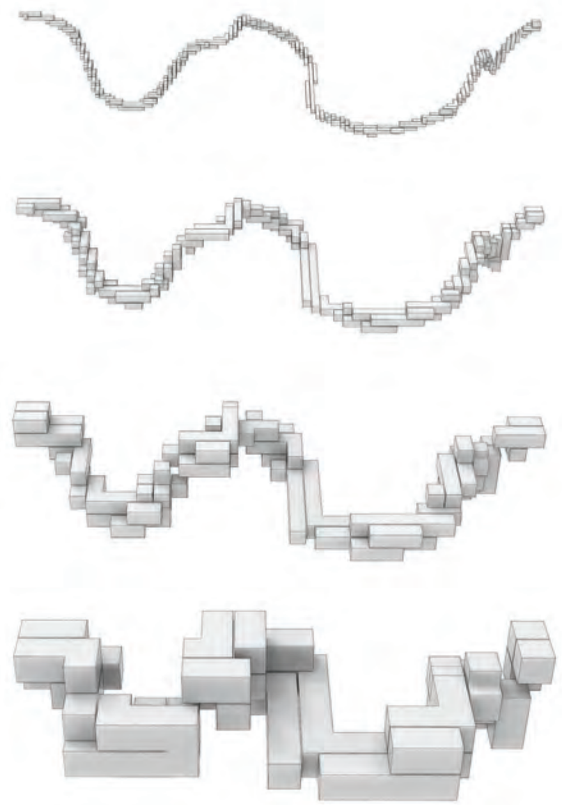


Figure 8: Digital and Discrete version of Greg Lynn's NURBS curve, Gilles Retsin (2016)

Figure 9: Suncheon Art Platform, Gilles Retsin Architecture (2016)

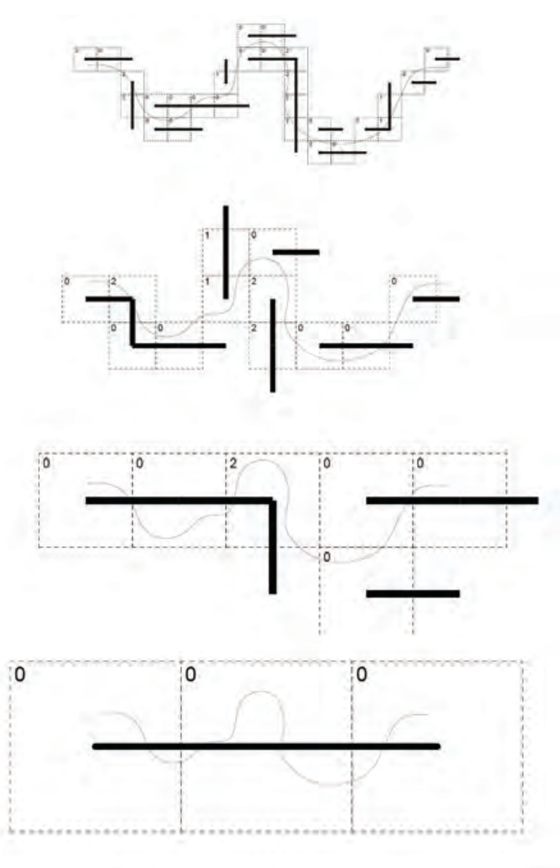


Figure 10: Digital and Discrete version of Greg Lynn's NURBS curve, Gilles Retsin Architecture (2016). "How Low Can You Go?"

literally a cube or voxel, suggesting a logical and rational endpoint for architecture where all questions concerning syntax and part-to-whole relations are irrelevant. This voxel-like block would enable a kind of warcraft-like post-digital, post-design world. The work below aims to take a different approach and tries to never assume a pixel- or block-like element, but rather an element that contains a certain kind of design agency and establishes particular relations between elements. The first experiment with this fully digital project is the Diamond House (2016) (fig. 6), a project for a multi-family home in Wemmel, Belgium. The project is based on an L-shaped and a rectilinear element with male-female connections. The elements are hollow, assembled out of timber sheet material. In principle, they could be produced on a small CNC router as a form of distributed manufacturing. The elements are hierarchically scalable, which means that they can appear at the same time on multiple different scales. Just as in the other examples, we first assume a space, filled up with points, that can contain data such as stress, vectors, etc. Each voxel is linked to a digital building block, which, for example, orients in the direction of the vector, or could obtain a specific position based on the neighboring voxels. A syntax emerges from the relations between elements (figs. 7A–C). Greg Lynn's NURBS curve diagram now becomes a volumetric, voxelized cloud of data. The content of the voxel, as well as the size or resolution of the voxel space, can be varied. Unlike the lofted NURBS surface, this discrete assembly is already three dimensional and tectonic[11] (fig. 8). It is non-geometrical and non-topological.

This digital syntax is independent of resolution; it remains the same on different scales. The Diamond House could be constructed with smaller elements or with large ones. Fundamentally, a shift in resolution does not affect the syntax and part-to-whole relations. This idea is shown in a series of diagrams where we change the resolution of Greg Lynn's curve, from a line that seems perfectly smooth down to a rough and low-resolution arrangement of straight lines (fig. 7C). This change in resolution puts into question the digital's affiliation with the idea of increased resolution, or ever larger amounts of elements and smaller scales of operation. In the end, a change in resolution is a quantitative argument, while the syntax—the relations between the elements—is a qualitative one. On a more pragmatic level, lowering the resolution can also result in more efficiency and feasibility. How far can we drive the resolution down before the object becomes something truly different? As a kind of provocation, the last diagram shows how Greg Lynn's curve is reduced to a single, straight line—still syntactically the same as the more complex high-resolution assemblies. This approach is explored in the competition proposal for the Suncheon Art Platform (2016) (fig. 9), which uses large-scale building blocks. These blocks are made of timber panels with internal stiffening frames. In total, the building consists of 237 blocks. Services such as ventilation and museum lighting are integrated in the blocks. The competition proposal explores the implications of this lower resolution, arguing that the most important aspect is the syntax. So although the resolution is low, and the building may at times seem almost minimal, it's still a digital material organization, syntactically the same as the Diamond House. The Suncheon Art Platform argues that resolution or scale is not as important as syntax. The lower resolution syntax in the Suncheon Art Platform emphasizes the shift from an emphasis on whole to an emphasis on parts. The building has a strong and clear figure, but at the same time, this figure remains diffused and open; it could expand, contract, etc. There is a blurry, albeit pixelated, boundary between the outside environment and the inside. So instead of a subdivision of the whole, sliced into a large amount of customized parts, we now have a building form that is in conversation with the part and whole; these are democratically situated on the same plane (Bryant 2014). This could be described as an "in part whole" or "unfinished whole"—a play on the seemingly contradictory mutual autonomy of part and whole. Jose Sanchez uses the term "Open Whole" to capture the adaptability and democratic quality of this type of design (Sanchez 2016).

The Diamond House and Suncheon Art Platform are fully digital, both in the design process, in material organization and syntax, and as an economic model or production. Similar to the WikiHouse, these building blocks could be understood as elements which can be fabricated without the need for a large production chain. They can be cut and assembled out of small sections of sheet materials, using widely available tools such as CNC machines. The use of a single element radically reduces the complexity of building. Instead of large amounts of different suppliers and subcontractors, there is only one building element. As Gerschenfeld points out, these digital materials are inherently more efficient for robotic assembly (Gerschenfeld 2015). Research by UCL Bartlett RC-4 into robotic assembly of discrete elements has further explored this point. The research has explored additive manufacturing with versatile, serialized building blocks similar to the ones in the Diamond House (fig. 12) (Retsin, Jimenez, and Soler 2017). The Diamond House is prototypical for this approach to discrete robotic assembly. The high degree of serial repetition and limited set of connectivity problems make feasible a fully automated robotic assembly process (Retsin 2016).

This also has major architectural consequences: it

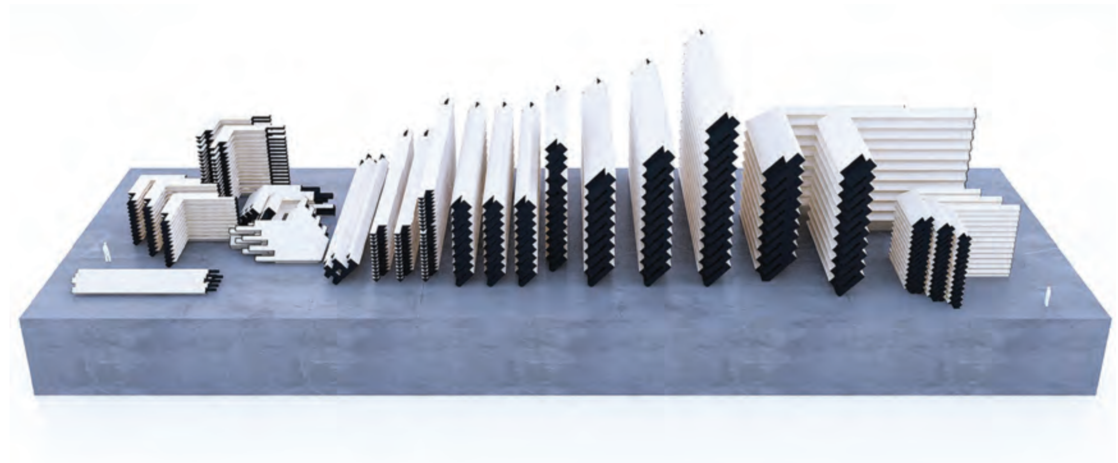


Figure 11: Suncheon Art Platform, Gilles Retsin Architecture (2016). 278 engineered timber elements.

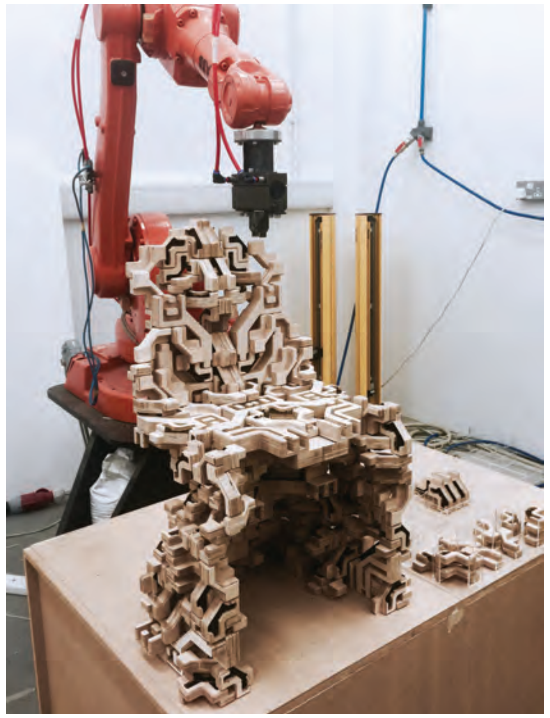


Figure 12: UCL Bartlett RC4, Team INT, Robotically Assembled Chair. Tutors: Gilles Retsin and Manuel Jimenez. Students: Claudia Tanskanane, Zoey Hwee Ting Tan, Qianyi Li, and Xiaolin Yi.

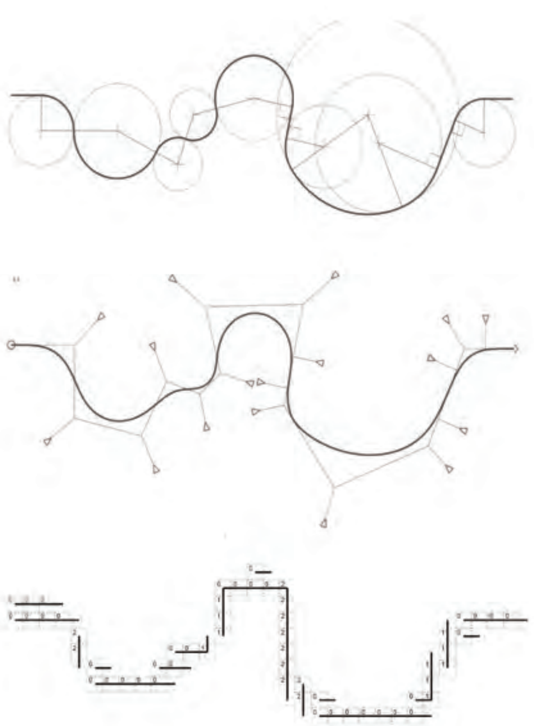


Figure 13: Digital and Discrete version of Greg Lynn's NURBS curve, Gilles Retsin Architecture (2016). Modernist Assembly vs. Digital Assembly.

results in a form of assembly which is completely different from modernist assembly. Le Corbusier's Maison Dom-Ino is an assembly of elements that relate to a particular function or type: a column, stair, floor slab, etc. Compared to a digital syntax, there is only a limited set of possible relations between the elements. A discrete assembly as in the Diamond House uses one element, which is initially meaningless—almost like a pixel. It is only after combination with other elements that it establishes a meaning or function: a specific combination emerges as something that acts as a load-bearing structure, or something we would understand as a column. So although the Diamond House articulates itself in a series of structures that *look* like columns and slabs, in fact these do not exist. To paraphrase René Magritte here—"ceci n'est pas une colonne"—*this is not a column*; these are merely a number of discrete elements, which, in this case, may look like a column to you, as an observer. In terms of part-to-whole relations and syntax, there are in fact no such things as columns or slabs in the Diamond House. Also, compared to structuralism or late modernism, which engaged more with prefabrication and the notion of the element, we can see that the syntax—the mode of composition—has changed. There is no more understanding of a rigid and fixed modular assembly based on a static Cartesian grid. The type of assembly we see in the digital syntax does make use of a voxel grid, but this is a data structure, a set of relations, not a geometrical entity. Although the structuralist project is discrete, in the sense that it is an assembly, it is not yet digital.

THE CONSEQUENCES OF BEING DIGITAL

This article has laid out a series of arguments and discussions about the relationship between "the digital" and architecture. The criticism that "we have never been digital" is not a negative, counter-argument, but is meant as something propositional, continuing the project of the digital in architecture in the long run, post-2008. This text has advanced the Digital and Discrete, as a propositional argument for another way to think about the digital and architecture, driven by the notion of a digital building block. It is an invitation to leave the surface behind, to recolonize the depth of architecture, fundamentally questioning how it is produced, distributed, and given form.

The article points out that what we consider "digital" in architecture, may in fact be analog. Architects have consistently misunderstood the nature of the digital, and have mainly based their argument on "the affordance" of computer controlled machines to create differentiated forms. This analog approach to digital manufacturing has led to a situation in which architecture is reduced to a surface and disconnected from the actual economic and political implications of digital manufacturing tools. The discretized and digital version of Greg Lynn's NURBS curve is not a curve anymore; it has left the domain of the organic, the differentiated, the geometry of curves and surfaces. This digital "curve" made of discrete building blocks shares the notion of assembly with the modernist curve Lynn refers to. However, this is a completely different form of assembly, not based on geometry and fixed types, but on a digital logic of universal units. The modernist understanding of architecture as an assemblage of prefabricated, discrete elements enters into an unexpected new domain of the digital, resulting in previously unachievable detail, materiality, structure, and aesthetics (fig. 13).

Apart from the more architectural questions related to syntax and part-to-whole relations, the focus on digital production beyond mere formal differentiation sets up a discussion about the potential social agency of this tool. It enables the possibility of architects engaging the digital in a larger social discussion. At the same time, the focus on parts, composition, and syntax keep this discussion firmly grounded in design. In the digital-discrete, the political engagement is integrated: digital fabrication tools are understood as a way to engage with modes of production, and therefore also with social and political ideas. Rather than participating in isolated conversation about material behavior and structural performance, architects can use their understanding of digital workflows to contribute ideas to a vivid cultural and political debate about the future of capitalism, automation, the status of the city, housing, etc.

ENDNOTES

1. "We have never been digital" and the link with Latour and Negroponte has been first used by Thomas Haigh, in the context of digital humanities. The statement here does not refer to Thomas Haigh's article, which is rather skeptical of the impact of digital technologies.

2. With the "post-digital," I refer here to a large body of work by a new generation of practitioners, encompassing people directly referring to themselves as "post-digital," but also the recent wave of Object Oriented Ontology-inspired work.

3. Carpo refers to the work of EZCT, Biot(h)ing, Kokkugia and Michael Hansmeyer.

4. This argument has also been used before by Neil Leach, who contends that "there is no such thing as digital architecture." See: 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 and Mariana Ibañez (Los Angeles: eVolo Press, 2014) 148–58.

5. For more on mereology in architecture, see: Daniel Köhler, *The Mereological City: A Reading of the Works of Ludwig Hilberseimer* (Bielefeld: Transcript Verlag, 2016).

6. A quick Google Trends search graph shows the decline in popularity of the term "mass customization."

7. Although Nick Srnicek is skeptical about the possibility of competing with platforms (Srnicek 2016).

8. Mereological Nihilism, or Compositional Nihilism, is the negation that Objects with proper parts exist. See Peter van Inwagen.

9. Boids as in Craig Reynolds' algorithm.

10. Such as, for example, the Baltic Air Terminal by Kokkugia with Buro Happold (2010).

11. It's important to distinguish the system described above from operations based on mere aggregation, where the geometry of the part defines the whole. See, for example, *BLOOM*, by Alisa Andrasek and Jose Sanchez. This voxel organization is also fundamentally different from a spatial subdivision or tessellation, which is again geometrical, as in, for example, the work by Aranda\Lasch.

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