Prospectives

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Architecture Theory

City Architecture

Composition

Digital

Discrete Architecture

Mereologies

Mereology

Urban Design

Issue 1

Curated by:
Daniel Koehler

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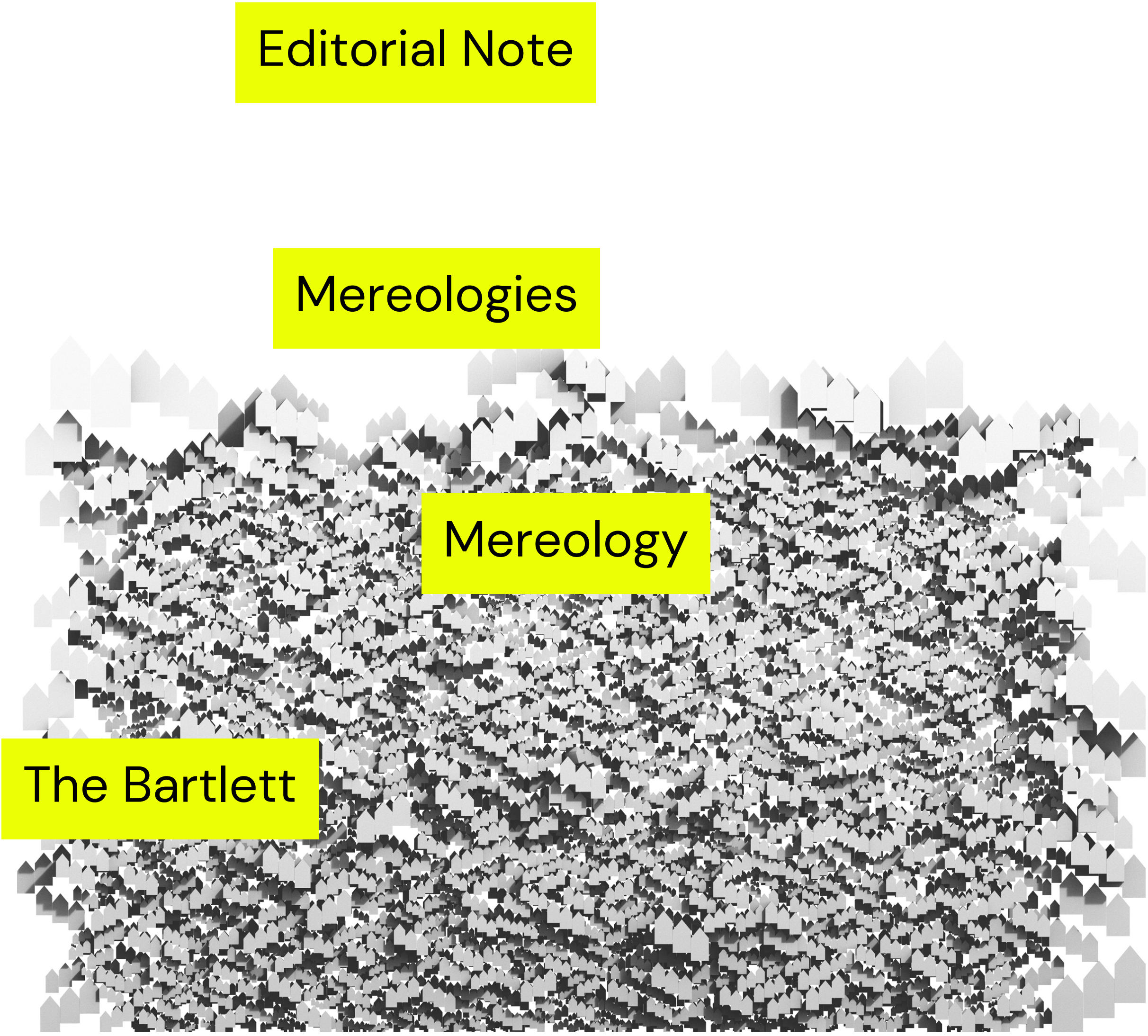

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Welcome to *Prospectives*.

Prospectives is an open-access online journal dedicated to the promotion of innovative historical, theoretical and design research around architectural computation, automation and fabrication technologies published by B–Pro at The Bartlett School of Architecture, UCL. It brings the most exciting, cutting-edge exploration and research in this area onto a global stage. It also aims to generate cross-industry and cross-disciplinary dialogue, exchange and debate about the future of computational architectural design and theoretical research, linking academic research with practice and industry.

Featuring emerging talent and established scholars, as well as making all content free to read online, with very low and accessible prices for purchasing issues, *Prospectives* aims to unravel the traditional hierarchies and boundaries of architectural publishing. The Bartlett supports a rich stream of theoretical and applied research in computational design, theory and fabrication. We are proud to be leading this initiative via an innovative, flexible and agile website. Computation has changed the way we practice, and the theoretical constructs we use – as well as the way we publish.

Prospectives has been designed to be a part-automated, part-human, multiplicitous platform. You may come across things when using it that do not feel, well, quite human. You may not realise at first that you are looking at something produced by automation. And because every issue is unique yet sitting within a generative framework this may mean you see the automation behind *Prospectives* do things that humans may not do.

Furthermore how you engage with *Prospectives* is largely left up to the reader. You can read our guest-curated issue, and use the tags to generate your own unique issue – an 'issue within an issue' – or read individual articles. You can also suggest new tags to be adopted by articles. We hope this provokes new ways of thinking about the role that participation, digitisation and automation can play in architectural publishing. *Prospectives* in a work-in-progress, and its launch is the first step towards fulfilling a vision for new kinds of publishing platforms for architecture that play with, and provoke, the discourse on computation and automation in architectural design and theory research.

Issue 01: Mereologies

"Mereologies", or the plural form of being 'partly', drives the explorations bundled in the first issue of *Prospectives*, guest curated by Daniel Koehler, Assistant Professor at University of Texas at Austin, previously a Teaching Fellow at The Bartlett School of Architecture from 2016 to 2019.

Today, architects can design directly with the plurality of parts that a building is made of due to increased computational power. What are the opportunities when built space is computed part-to-part? Partly philosophy, computation, sociology ecology and partly architecture, each text – or "mereology" – contributes a particular insight on part relations, linking mereology to peer-to-peer approaches in computation, cultural thought, and built space. First substantiated in his PhD at the University of Innsbruck, published in 2016 as *The Mereological City: A Reading of the Works of Ludwig Hilberseimer* (transcript), Daniel's work on mereology and part-hood – as an nuanced interplay and blurring between theory and design – has been pivotal in breeding the ground for an emerging generation of architects interested in pursuing a new ethical and social project for the digital in architecture. The collection of writings curated here included postgraduate architecture and urban design students (both his own, and others), architecture theorists, designers, philosophers, computer scientists and sociologists. The interdisciplinary nature of this issue demonstrates how mereology as a subject area can further broaden the field of architecture's boundaries. It also serves as a means of encapsulating a contemporary cultural moment by embedding that expanding field in core disciplinary concerns.

The contributions were informed by research and discussions in the Bartlett Prospectives (B-Pro) at The Bartlett School of Architecture, UCL London, from 2016 to 2019, culminating in an Open Seminar on mereologies, which took place on 24 April 2019 as part of the Prospectives Lecture Series in B-Pro. Contributors to this issue include: Jordi Vivaldi, Daniel Koehler, Giorgio Lando, Herman Hertzberger, Anna Galika, Hao Chen Huang, Sheghaf Abo Saleh, David Rozas, Anthony Alvidrez, Shivang Bansal and Ziming He.

Acknowledgements

Prospectives has been a work-in-progress for almost 10 years. The dream of Professor Frédéric Migayrou (Chair of School and Director of B–Pro at The Bartlett School of Architecture) when he arrived at The Bartlett in 2011, I became involved in the project when I joined the School 1 year later. It has been a labour of love and perseverance since. It is due to the fervent and ardent support of Frédéric, Professor Bob Sheil (Director of School), and Andrew Porter (Deputy Director of B–Pro) that this project later received funding in 2018 to formalise the development of *Prospectives*. To the B–Pro Programme Directors Professor Mario Carpo, Professor Marcos Cruz, Roberto Bottazzi, Gilles Retsin and Manuel Jimenez: I am thankful for your guidance, advice and friendship which has been paramount to this project. Colleagues such as Barbara Penner, Yeoryia Manolopoulou, Barbara Campbell-Lange, Matthew Butcher, Jane Rendell, Claire McAndrew, Clara Jaschke and Sara Shafei have all given me an ear (or a talking to!) at various stages when this project most needed it.

Finally, it is important to say that schools of architecture like the Bartlett have cross-departmental and cross-faculty teams who are often the ones who breed the ground for projects such as *Prospectives* to be possible. The research, expertise and support of Laura Cherry, Ruth Evison, Therese Johns, Professor Penelope Haralambidou, Manpreet Dhesi, Professor Laura Allen, Andy O'Reilly, Gill Peacock, Sian Lunt and Emer Girling has been vital – thank you.

Article 2 : Introduction to Issue 01: Mereologies

25/10/2

Architecture

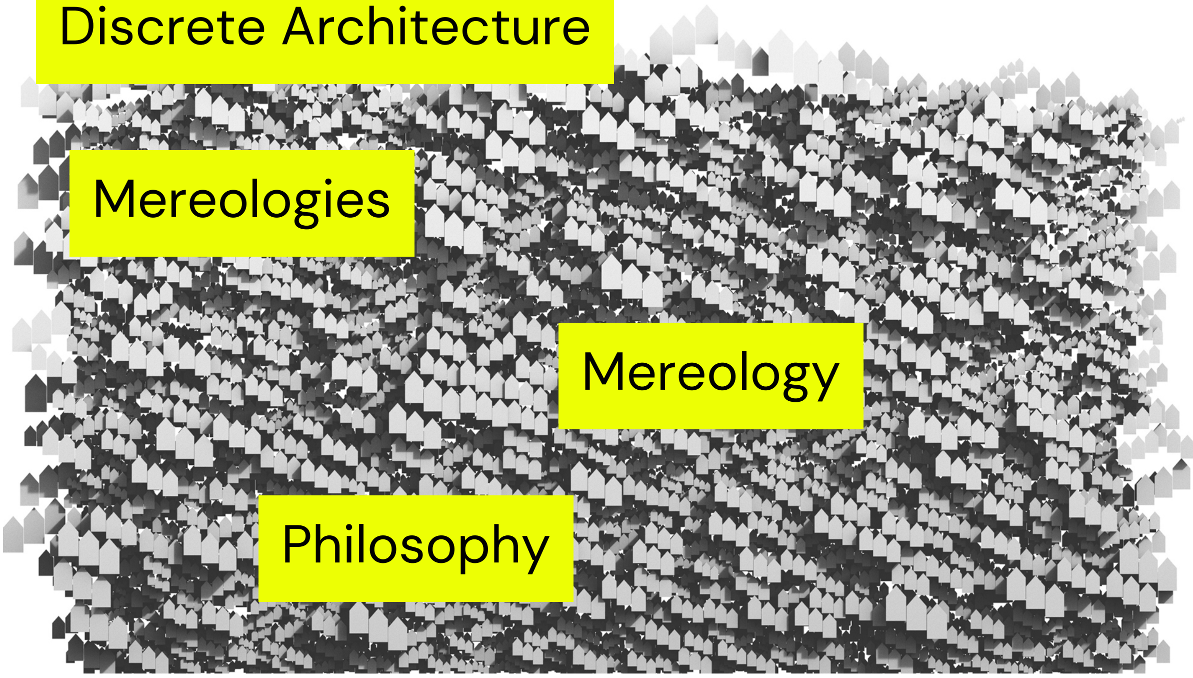
Architecture Theory

Discrete Architecture

Mereologies

Mereology

Philosophy



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Part relationships play an important role in architecture. Whether an aspect of a Classical order, a harmonious joining of building components, a representation of space, a partition of spaces, or as a body that separates us and identifies us as individuals. From the very outset, every form of architecture begins with an idea of how parts come together to become a whole and an understanding of how this whole relates to other parts. Architecture first composes a space as a part of a partitioning process well before defining a purpose, and before using any geometry.

The sheer performance of today's computational power makes it possible to form a world without a whole, without any third party or a third object. Ubiquitous computing fosters peer-to-peer or better part-to-part exchange. It is not surprising then that today's sharing represents an unfamiliar kind of partiality. From distributive manufacturing to the Internet of Things, new concepts of sharing promise systematic shifts, from mass-customisation to mass-individualisation: the computational enabled participations are foundational. It is no longer the performance or mode of an algorithm that drives change but its participatory capacities. From counting links, to likes, to seats, to rooms: tools for sharing have become omnipresent in our everyday lives. Thus, that which is common is no longer negotiated but computed. New codes – not laws or ideologies – are transforming our cities at a rapid pace, but what kind of parthood is being described? How does one describe something only through its parts today? To what extent do the automated processes of sharing differ from the partitioning of physical space? How can we add, intervene and design such parts through architecture?

The relationship between parts and their whole is called Mereology. In this issue of *Prospectives*, mereology's theories and the specifics of part-relations are explored. The differences between parts and the whole, the sharing of machines and their aesthetics, the differences between distributive and collective, their ethical commitments, and the possibilities of building mereologies are discussed in the included articles and interviews.

Just as mereology describes objects from their parts, this issue is partial. It is not a holistic proposal, but a collection of positions. Between philosophy, computation, ecology and architecture, the texts are reminders that mereologies have always been part of architecture.

Mereology is broadly a domain that deals with compositional possibilities, relationships between parts. Such an umbrella – analogue to morphology, typology, or topology – is still missing in architecture. Design strategies that depart part-to-part or peer-to-peer are uncommon in architecture, also because there is (almost) no literature that explores these topics for architectural design. This issue hopes to make the extra-disciplinary knowledge of mereology accessible to architects and designers, but also wishes to identify links between distributive approaches in computation, cultural thought and built space.

The contributions gathered here were informed by research and discussions in the Bartlett Prospectives (B-Pro) at The Bartlett School of Architecture, UCL London from 2016 to 2019, culminating in an Open Seminar on mereologies which took place on 24 April 2019 as part of the Prospectives Lecture Series. The contributions are intended as a vehicle to inject foundational topics such as mereology into architectural design discourse.

The Contributions

This compilation starts with Giorgio Lando's text "Mereology and Structure". Lando introduces what mereology is for philosophers, and why philosophers discuss mereological theses, as well as disagree one with another about them. His text focuses in particular on the role of structure in mereology outlining that from a formal point of view part relations are freed from structure. He argues that independence from structure might be the identifying link between mereology and architecture. The second article "From Partitioning to Partaking" is a plea for re-thinking the city. Daniel Koehler's essay points to the differences between virtual and real parts. Koehler observes a new spatial practice of virtual representations that render previous models of urban governance obsolete. He argues that the hyper-dimensional spaces of a big data-driven economy demand a shift from a partitioning practice of governance to more distributed forms of urban design. In "Matter versus Parts: The Immaterialist Basis of Architectural Part-Thinking" Jordi Vivaldi Piera highlights the revival of matter in parallel to the discrete turn in contemporary discourses on experimental architecture. The essay gravitates around the notion of part-thinking in association with the notion of form. Fluctuating between continuous and discrete, the text sets out requirements for radical part-thinking in architecture. As a computational sociologist, David Rozas illustrates the potential of decentralised technologies for democratic processes at the scale of neighborhood communities. After an introduction to models of distributed computation, "Affordances of Decentralised Technologies for Commons-based Governance of Shared Technical Infrastructure" draws analogies to Elinor Ostrom's principles of commons governance and how those can be computationally translated, turning community governance into fully decentralised autonomous organisations.

Departing from the Corbusian notion of a 'machine for living', Sheghaf Abo Saleh defines a machine for thinking. In "When Architecture Thinks! Architectural Compositions as a Mode of Thinking in the Digital Age" Abo Saleh states that the tectonics of a machine that thinks is brutal and rough. As a computational dialogue, she shows how roughness can enable posthumanism which, in her case, turns "tempered" parts into a well-tempered environment. Ziming He's entry point for "The Ultimate Parts" is the notion of form as the relations between parts and wholes. He's essay sorts architectural history through a mereological analysis, proposing a new model of part-to-part without wholes. Shivang Bansal's "Towards a Sympoietic Architecture: Codividual Sympoiesis as an Architectural Model" investigates the potential of sympoiesis. By extending Donna Haraway's argument of "tentacular thinking" into architecture, the text shifts focus from object-oriented thinking to parts. Bansal argues for the limits of autopoiesis as a system and conceptualises spatial expressions of sympoiesis as a necessity for an adaptive and networked existence through "continued complex interactions" among parts.

Merging aspects of 'collective' and 'individuality,' in "Codividual Architecture within Decentralised Autonomous System" Hao Chen Huang proposes a new spatial characteristic that she coins as the "codividual". Through an architectural analysis of individual and shared building precedents, Huang identifies aspects of buildings that merge shared and private features into physical form. Anthony Alviraz's paper "Computation Within Codividual Architecture" investigates the history and outlook of computational models into architecture. From discrete to distributed computation, Alviraz speculates on the implications of physical computation where physics interactions overcome the limits of automata thinking. In **"**Synthesizing Hyperumwelten"**,** Anna Galika transposes the eco-philosophical concept of an HyperObject into a "Hyperumwelt". While the Hyperobject is a closed whole that cannot be altered, a

Hyperumwelt is an open whole that uses objects as its parts. The multiple of a Hyperumwelt offers a shift from one object's design towards the impact of multiple objects within an environment.

Challenging the notion of discreteness and parts, Peter Eisenman asks in the interview "Big Data and the End of Architecture Being Distant from Power" for a definition of the cultural role of the mereological project. Pointing to close readings of postmodern architecture that were accelerated by the digital project, Eisenman highlights that the demand for a close reading is distanced from the mainstream of power. The discussion asks: ultimately, what can an architecture of mereology critique? The works of Herman Hertzberger are an immense resource on part-thinking. In the interview "Friendly Architecture: In the Footsteps of Structuralism", Herman Hertzberger explains his principle of accommodation. When building parts turn into accommodating devices, buildings turn into open systems for staging ambiguity.**

The issue concludes with a transcript from the round table discussion at the Mereologies Open Seminar at The Bartlett School of Architecture on 24 April 2019.

Acknowledgments

The contributions evolved within the framework of Bartlett Prospectives (B-Pro) at The Bartlett School of Architecture, UCL. I want to thank Frédéric Migayrou for his vision, commitment and long years of building up a research program, not only by architecture but through computation. I would like to thank Roberto Bottazzi for the years of co-organising the Prospectives Lecture Series, where plenty of the discussions that form the backbone of this issue took place. Thanks to Mario Carpo for raising the right question at the right time for so many people within the program, thanks to Andrew Porter for enabling so many events, to Gilles Retsin, for without the discrete there are no parts, Mollie Claypool for the editing and development of *Prospectives* journal, and Vera Buehlmann, Luciana Parisi, Alisa Andrasek, Keller Easterling, Matthew Fuller, John Frazer, Philippe Morel, Ludger Hovestadt, Emmanuelle Chiappone-Piriou, Jose Sanchez, Casey Rehm, Tyson Hosmer, and Jordi Vivaldi Piera for discussions and insights.

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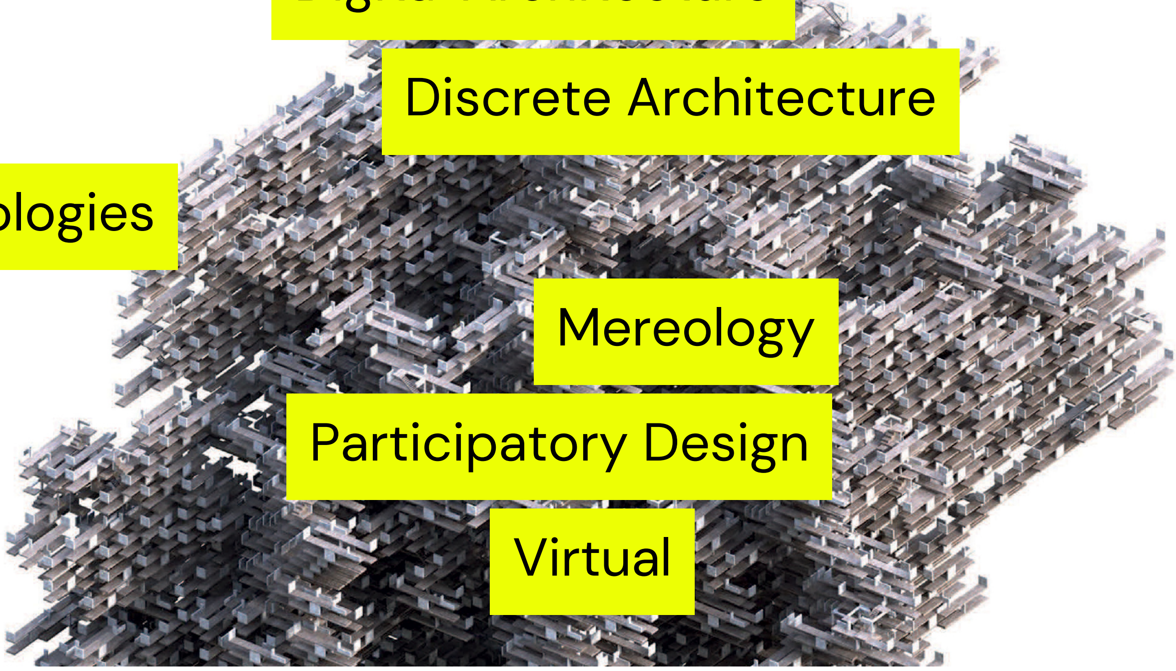
The issue includes articles that evolved from thesis reports conducted in the following clusters: Ziming He from Research Cluster 3 tutored by Tyson Hosmer, David Reeves, Octavian Gheorghiu, and Jordi Vivaldi in architecture theory. Sheghaf Abo Saleh, Anthony Alvidrez, Shivang Bansal, Anna Galika, Hao Chen Huang from Research Cluster 17 tutored by Daniel Koehler and Rasa Navasaityte. If not indicated directly, the featured images, graphics of this issue are by Daniel Koehler, 2020.

Article 3 : From Partitioning to Partaking, or Why Mereologies Matter

Architecture
Building
Digital
Digital Architecture
Discrete Architecture
Mereologies
Mereology
Participatory Design
Virtual



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Parts, chunks, stacks and aggregates are the bits of computational architecture today. Why do mereologies – or buildings designed from part-to-whole – matter? All too classical, the roughness of parts seems nostalgic for a project of the digital that aims for dissolving building parts towards a virtual whole. Yet if parts shrink down to computable particles and matter, and there exists a hyper-resolution of a close to an infinite number of building parts, architecture would dissolve its boundaries and the capacity to frame social encounters. Within fluidity, and without the capacity to separate, architecture would not be an instrument of control. Ultimately, freed from matter, the virtual would transcend from the real and form finally would be dead. Therein is the prospect of a fluid, virtual whole.

The Claustrophobia of a City that Transcends its Architecture

In the acceleration from Data to Big Data, cities have become more and more virtual. Massive databases have liquefied urban form. Virtual communication today plays freely across the material boundaries of our cities. In its most rudimentary form virtuality is within the digital transactions of numbers, interests and rents. Until a few years ago, financial investments in architectural form were equatable according to size and audience, e.g. as owner-occupied flats, as privately rented houses or as lease holding.[1] Today capital flows freely scatter across the city at the scale of the single luxury apartment. Beyond a certain threshold in computational access, data becomes big. By computing aggregated phone signal patterns or geotagged posts, virtual cities can emerge from the traces of individuals. These hyperlocal patterns are more representative of a city than its physical twin. Until recently, architecture staged the urban through shared physical forms: the sidewalk, lane or boulevard. Adjacent to cars, walkable for pedestrians or together as citizens, each form of being urban included an ideology of a commons, and grounded with that particular parts of encountering.

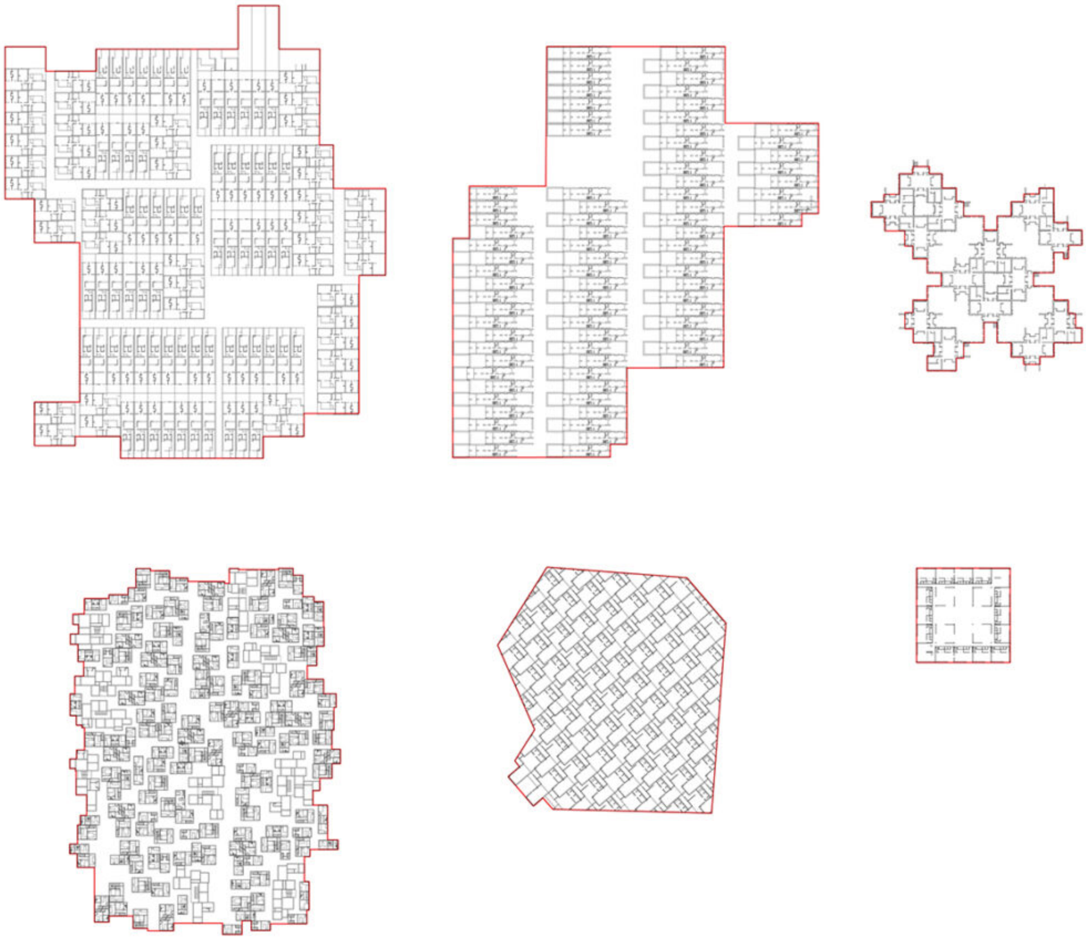


Figure 1 – (left to right) Floor area comparisons between housing projects from the Brutalist era (top) and today (bottom): Previ, Atelier 5 vs Seguro, Kerez La Sainte-Baume, Le Corbusier vs The Mountain, BIG; La Muralla Roja Calpe, Bofill vs Communal Villa, Dogma. Image: Daniel Koehler.

In contrast, a hyper-local urban transcends lanes and sidewalks. Detached from the architecture of the city, with no belonging left, urban speculation has withdrawn into the private sphere. Today, urban value is estimated by counting private belongings only, with claustrophobic consequences. An apartment that is speculatively invested displaces residents. The housing shortage in the big cities today is not so much a problem of lack of housing, but instead of vacant space, accessible not to residents but to interests they hold in the hyper-urban.[2] The profit from rent and use of space itself is marginal compared to the profit an embodied urban speculation adds to the property. The possibility of mapping every single home as data not only adds interest, like a pension to a home but literally turns a home into a pension.[3] However this is not for its residents but for those with access to resources. Currently, computing Big Data expands and optimises stakeholders' portfolios by identifying undervalued building assets.[4] However, the notion of 'undervalued' is not an accurate representation of assets.

Hyper-localities increase real estate's value in terms of how their inhabitants thrive in a neighbourhood through their encounters with one another and their surrounding architecture. The residents themselves then unknowingly produce extra value. The undervaluing of an asset is the product of its residents, and like housework, is unpaid labour. In terms of the exchange of capital, additional revenue from a property is usually paid out as a return to the shareholders who invested in its value. Putting big data-driven real estate into that equation would then mean that they would have to pay revenues to their residents. If properties create surplus value from the data generated by their residents, then property without its residents has less worth and is indeed over-, but not under-, valued.

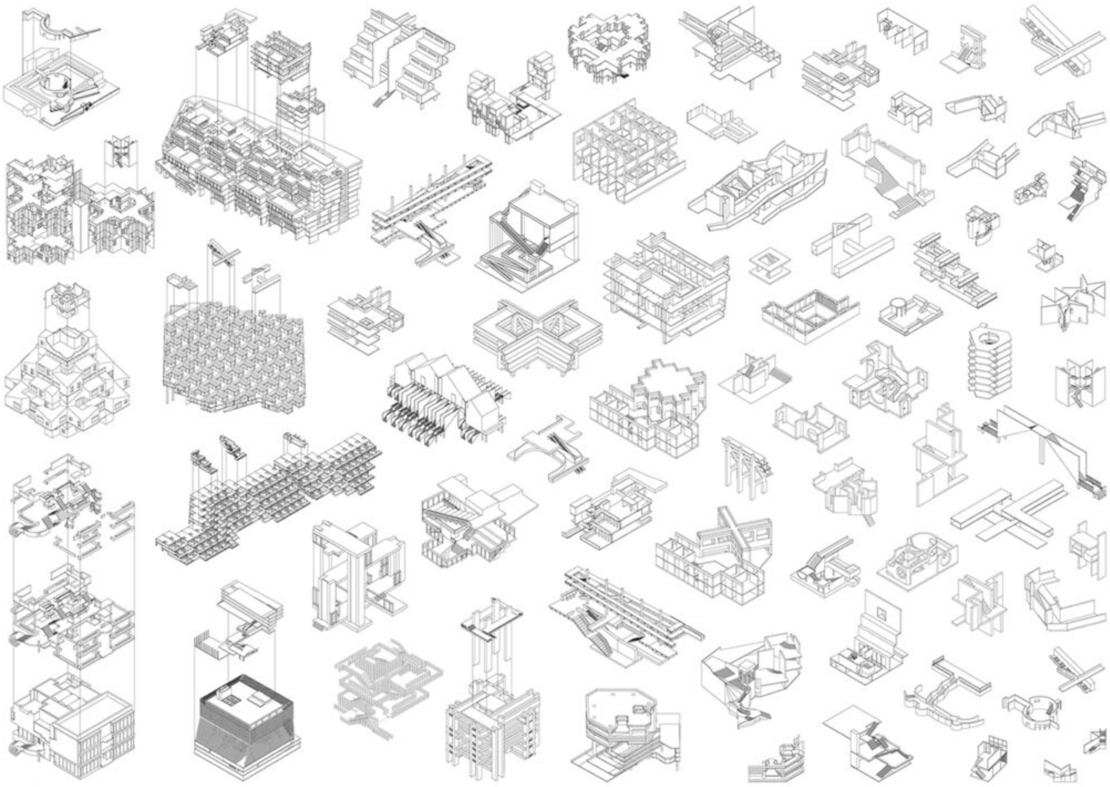


Figure 2 – (left to right) City in a Building, City as a Building and City as an Element of Architecture. Image: University of Innsbruck, Daniel Koehler with Martin Danigel and Jordi Vivaldi, 2016-2018.

The city uses vehicles for creating public revenue by governing the width of a street's section or the height of a building. Architecture's role was to provide a stage for that revenue to be created. For example the Seagram Building (van der Rohe, Johnson, 1958) created a "public" plaza by setting back its envelope in exchange for a little extra height. By limiting form, architecture could create space for not only one voice, but many voices. Today, however, the city's new parameters hidden in the fluidity of digital traces cannot be governed by the boundaries of architecture anymore. Outlined already 40 years ago, when the personal computer became available, Gilles Deleuze forecasted that "Man is not anymore man enclosed".[5] At that time, and written as a "Postscript on the Societies of Control", the fluid modulation of space prospected a desirable proposition. By liquefying enclosures, the framework of the disciplinary societies of Foucault's writings would disappear. In modern industrial societies, Deleuze writes, enclosures were moulds for casting distinct environments, and in these vessels, individuals became masses of the mass society.[6] For example, inside a factory, individuals were cast as workers, inside schools as students. Man without a cast and without an enclosure seemed to be freed from class and struggle. The freedom of an individual was interlinked with their transcendence from physical enclosures.

Figure 3 – The Hyper-Nollie Plan, Daniel Koehler, 2019. Image: Daniel Koehler, 2019.

During the last forty years, the relation between a single individual and the interior framed architecture rightly aimed to dissolve the institutional forms of enclosures that represented social exclusion at their exterior. Yet, in this ambition alternative forms for the plural condition of what it means to be part of a city were not developed. Reading Deleuze further, a state without enclosures also does not put an end to history. The enclosures of control dissolve only to be replaced. Capitalism would shift to another mode of production. When industrial exchange bought raw materials and sold finished products, now it would buy the finished products and profit from the assemblies of those parts. The enclosure is then exchanged with codes that mark access to information. Individuals would not be moulded into masses but considered as individuals: accessed as data, divided into proper parts for markets, "counted by a computer that tracks each person's position enabling universal modulation."[7] Forty years in, Deleuze's postscript has become the screenplay for today's reality.

Hyper-parts: Spatial Practices of representations

A house is no longer just a neutral space, an enclosing interior where value is created, realised and shared. A home is the product of social labour; it is itself the object of production and, consequently, the creation of surplus value. By shifting from enclosure to asset, the big data-driven economy has also replaced the project behind modernism: humanism. Architecture today is post-human. As Rosi Braidotti writes, "what constitutes capital value today is the informational power of living matter itself".[8] The human being as a whole is displaced from the centre of architecture. Only parts of it, such as its "immanent capacities to form surplus-value", are parts of a larger aggregation of architecture. Beyond the human, the Hyper-city transcends the humane. A virtual city is freed from its institutions and constituent forms of governance. Economists such as Thomas Piketty describe in painstaking detail how data-driven financial flows undermine common processes of governance, whether urban, regional, or national, in both speed and scale. Their analysis shows that property transactions shelled in virtual value-creation-bonds are opaque to taxation. Transcending regulatory forms of governance, one can observe the increase of inequalities on a global scale. Comparable to the extreme wealth accumulation at the end of the nineteenth century, Piketty identifies similar neo-proprietarian conditions today, seeing the economy shifting into a new state he coins as “hypercapitalism”.[9] From Timothy Morton’s “hyper-objects” to hypercapitalism, hyper replaces the Kantian notion of transcendence. It expresses not the absorption of objects into humanism, but its withdrawal. In contrast to transcendence, which subordinates things to man’s will, the hyper accentuates the despair of the partial worlds of parts – in the case of Morton in a given object and in the case of Piketty in a constructed ecology.

When a fully automated architecture emerged, objects oriented towards themselves, and non-human programs began to refuse the organs of the human body. Just as the proportions of a data center are no longer walkable, the human eye can no longer look out of a plus-energy window, because it tempers the house, but not its user. These moments are hyper-parts: when objects no longer transcend into the virtual but despair in physical space. More and more, with increasing computational performance, following the acronym O2O (from online to offline),[10] virtual value machines articulate physical space. Hyper-parts place spatial requirements. A prominent example is Katerra, the unicorn start-up promising to take over building construction using full automation. In its first year of running factories, Katerra advertises that it will build 125,000 mid-rise units in the United States alone. If this occurred, Katerra would take around 30% of the mid-rise construction market in the company’s local area. Yet its building platform consists of only twelve apartment types. Katerra may see the physical homogeneity as an enormous advantage as it increases the sustainability of its projects. This choice facilitates financial speculation, as the repetition of similar flats reduces the number of factors in the valuing of apartments and allows quicker monetary exchange, freed from many variables. Sustainability refers not to any materiality but to the predictability of its investments. Variability is still desired, but oriented towards finance and not to inhabitants. Beyond the financialisation of a home, digital value machines create their own realities purely through the practice of virtual operations.

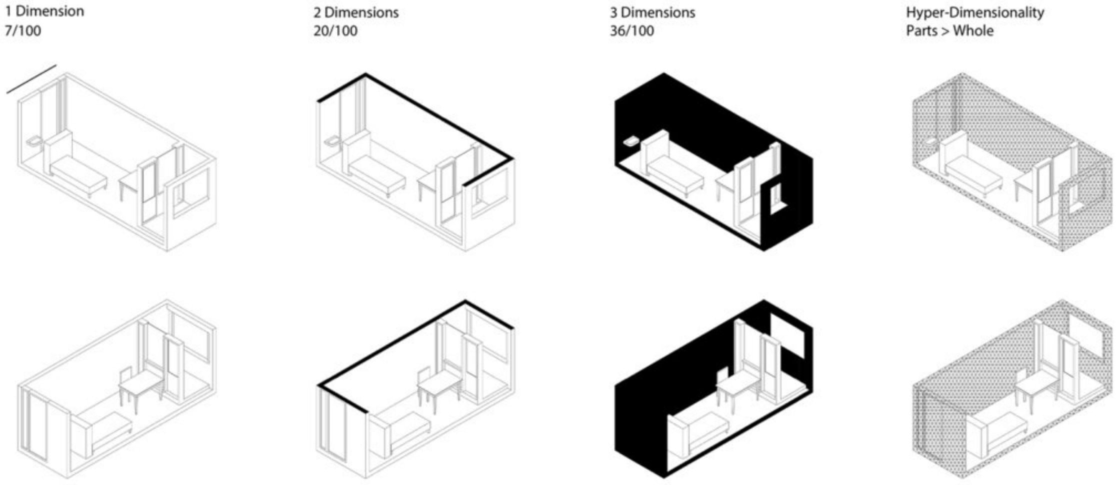


Figure 4 – The hyper-dimensional spaces of the digital economy are incompatible with cellular architecture. With every dimension added, the hull will gain weight until it absorbs more space than its content. From pure mathematical calculations, the dividends associated with the living cell and count more than its inhabitants. Image: Daniel Koehler, 2019.

Here one encounters a new type of spatial production: the spatialpractice of representations. At the beginning of what was referred to as“late capitalism”, the sociologist and philosopher Henri Lefebvreproposed three spatialities which described modes of exchange through capitalism.[11] The first mode, a spatial practice referred to a premodern condition, which by the use of analogies interlinked objects without any forms of representation—the second, representations of space linked directly to production, the organic schemes of modernism. The third representational spaces express the conscious trade with representations, the politics of postmodernism, and their interest invirtual ideas above the pure value of production. Though not limited tothree only, Lefebvre’s intention was to describe capitalism as “anindefinite multitude of spaces, each one piled upon, or perhaps containedwithin, the next”.[12] Lefebvre differentiated the stages in terms of theirspatial abstraction. Incrementally, virtual practices transcended from real-to-real to virtual-to-real to virtual-to-virtual. But today, decoupled fromthe real, a virtual economy computes physically within spatial practicesof representations. Closing the loop, the real-virtual-real, or new hyper-parts, do not subordinate the physical into a virtual representation, instead, the virtual representation itself acts in physical space.

This reverses the intention of modernism orientated towards an organic architecture by representing the organic relationships of nature in geometric thought. The organicism of today’s hypercomputation projects geometric axioms at an organic resolution. What was once a representation and a geometry distant from human activity, now controls the preservation of financial predictability.

The Inequalities Between the Parts of the Virtual and the Parts of the Real

Beyond the human body, this new spatial practice of virtual parts today transcends the digital project that was limited to a sensorial interaction of space. This earlier understanding of the digital project reduced human activity to organic reflexes only, thus depriving architecture of the possibility of higher forms of reflection, thought and criticism. Often argued through links to phenomenology and Gestalt theory, the simplification of architectural form to sensual perception has little to do with phenomenology itself. Edmund Husserl, arguably the first phenomenologist, begins his work with considering the perception of objects, not as an end, but to examine the modes of human thinking. Examining the logical investigations, Husserl shows that thought can build a relation to an object only after having classified it, and therefore, partitioned it. By observing an object before considering its meaning, one classifies an object, which means identifying it as a whole. Closer observations recursively partition objects into more unaffected parts, which again can be classified as different wholes.[13] Husserl places parts before both thought and meaning.

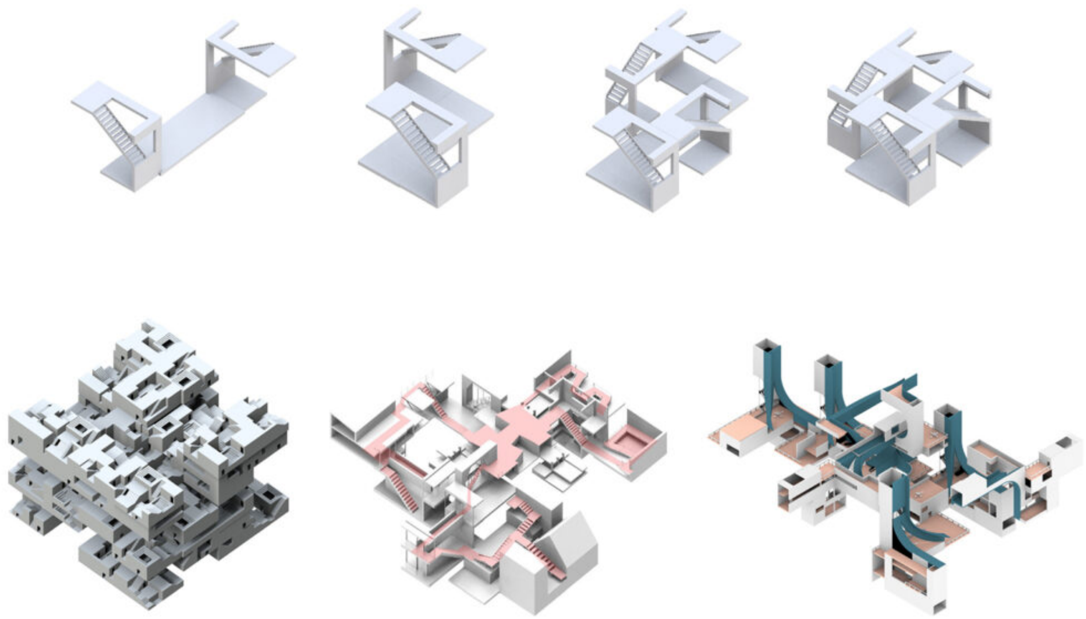


Figure 5 – Mereologies, 2016. Image(s): (top) Genmao Li, RC17, MArch Urban Design, B-Pro, The Bartlett School of Architecture, UCL, 2016; (bottom) Zhiyuan Wan, Chen Chen, Mengshi Fu, RC17, MArch Urban Design, B-Pro, The Bartlett School of Architecture, UCL, 2016.

Derived from aesthetic observations, Husserl's mereology was the basisof his ethics, and was therefore concluded in societal conceptions. In his later work, Husserl's analysis is an early critique of the modern sciences.[14] For Husserl, in their efforts to grasp the world objectively,the sciences have lost their role in enquiring into the meaning of life. In a double tragedy, the sciences also alienated human beings from the world. Husserl thus urged the sciences to recall that they ground their origins in the human condition, as for Husserl humanism was ultimately trapped in distancing itself further from reality.

One hundred years later, Husserl's projections resonate in "speculative realism". Coined By Levi Bryant as "strange mereology",[15] objects, their belongings, and inclusions are increasingly strange to us. The term "strange" stages the surprise that one is only left with speculative access. However, ten years in, speculation is not distant anymore. That which transcends does not only lurk in the physical realm. Hyper-parts figurate ordinary scales today, namely housing, and by this transcend the human(e) occupation.

Virtual and physical space are compositionally comparable. They both consist of the same number of parts, yet they do not. If physical elements belong to a whole, then they are also part of that to which their whole belongs. In less abstract terms, if a room is part of an apartment, the room is also part of the building to which the apartment belongs. Materially bound part relationships are always transitive, hierarchically nested within each other. In virtual space and the mathematical models with which computers are structured today, elements can be included within several independent entities. A room can be part of an apartment, but it can also be part of a rental contract for an embassy. A room is then also part of a house in the country in which the house is located. But as part of an embassy, the room is at the same time part of a geographically different country on an entirely different continent than the building that houses the embassy. Thus, for example, Julian Assange, rather than boarding a plane, only needed to enter a door on a street in London to land in Ecuador. Just with a little set theory, in the virtual space of law, one can override the theory of relativity with ease.

Parts are not equal. Physical parts belong to their physical wholes, whereas virtual parts can be included in physical parts but don't necessarily belong to their wholes. Far more parts can be included in a virtual whole than parts that can belong to a real whole. When the philosopher Timothy Morton says “the whole is always less than the sum of its parts”,[16] he reflects the cultural awareness that reality breaks due to asymmetries between the virtual and the real. A science that sets out to imitate the world is constructing its own. The distance which Husserl spoke of is not a relative distance between a strange object and its observer, but a mereological distance, when two wholes distance each other because they consist of different parts. In its effort to reconstruct the world in ever higher resolution, modernism, and in its extension the digital project, has overlooked the issue that the relationship between the virtual and the real is not a dialogue. In a play of dialectics between thought and built environment, modernism understood design as a dialogue. In extending modern thought, the digital project has sought to fulfill the promise of performance, that a safe future could be calculated and pre-simulated in a parallel, parametric space. Parametricism, and more generally what is understood as digital architecture, stands not only for algorithms, bits, and rams but for the far more fundamental belief that in a virtual space, one can rebuild reality. However, with each resolution that science seeks to mimic the world, the more parts it adds to it.

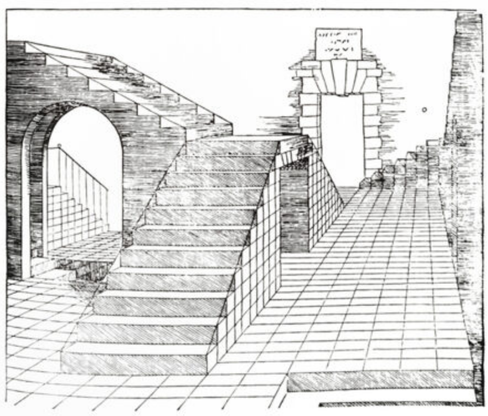


Figure 6 – Illustrations of exemplary stairs constructed through cubes, Sebastiano Serlio, 1566. Image: public domain.

The Poiesis of a Virtual Whole

The asymmetry between physical and virtual parts is rooted in Western classicism. In early classical sciences, Aristotle divided thinking into the trinity of practical action, observational theory and designing poiesis. Since the division in Aristotle's Nicomachean Ethics, design is a part of thought and not part of objects. Design is thus a knowledge, literally something that must first be thought. Extending this contradiction to the real object, design is not even concerned with practice, with the actions of making or using, but with the metalogic of these actions, the in-between between the actions themselves, or the art of dividing an object into a chain of steps with which it can be created. In this definition, design does not mean to anticipate activities through the properties of an object (function), nor to observe its properties (materiality), but through the art of partitioning, structuring and organising an object in such a way that it can be manufactured, reproduced and traded.

To illustrate poiesis, Aristotle made use of architecture.[17] No other discipline exposes the poetic gap so greatly between theory, activity and making. Architecture first deals with the coordination of the construction of buildings. As the architecture historian Mario Carpo outlines in detail, revived interest in classicism and the humanistic discourse on architecture began in the Renaissance with Alberti's treatise: a manual that defines built space, and ideas about it solely through word. Once thought and coded into words, the alphabet enabled the architect to physically distance from the building site and the built object.[18] Architecture as a discipline then does not start with buildings, but with the first instructions written by architects used to delegate the building.

A building is then anticipated by a virtual whole that enables one to subordinate its parts. This is what we usually refer to as architecture: a set of ideas that preempt the buildings they comprehend. The role of the architect is to imagine a virtual whole drawn as a diagram, sketch, structure, model or any kind of representation that connotates the axes of symmetries and transformations necessary to derive a sufficient number of parts from it. Architectural skill is then valued by the coherence between the virtual and the real, the whole and its parts, the intention and the executed building. Today's discourse on architecture is the surplus of an idea. You might call it the autopoiesis of architecture – or merely a virtual reality. Discourse on architecture is a commentary on the real.

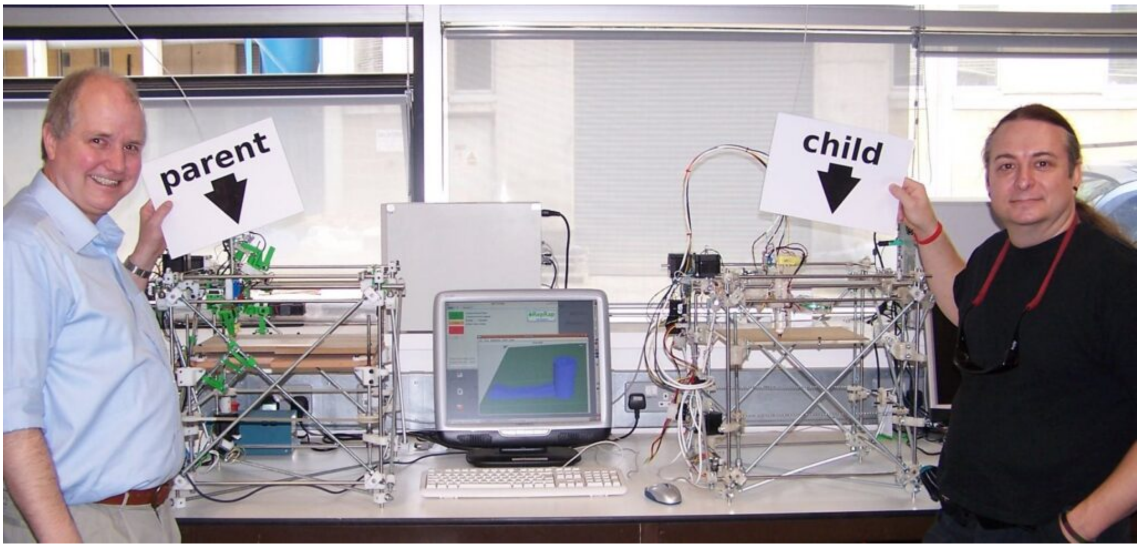


Figure 7 – Adrian Bowyer (left) and Vik Olliver (right) with a parent RepRap machine, and the first child machine, made by the RepRap on the left. Image: public domain.

Partitioning Architectures

From the very outset, architecture distanced itself from the building, yet also aimed to represent reality. Virtual codes were never autonomous from instruments of production. The alphabet and the technology of the printing press allowed Alberti to describe a whole ensemble distinct from a real building. Coded in writing, printing allowed for the theoretically infinite copies of an original design. Over time, the matrices of letters became the moulds of the modern production lines. However, as Mario Carpo points out, the principle remained the same.[19] Any medium that incorporates and duplicates an original idea is more architecture than the built environment itself. Belonging to a mould, innovation in architecture research could be valued in two ways. Quantitatively, in its capacity to partition a building in increasing resolution. Qualitatively, in its capacity to represent a variety of contents with the same form. By this, architecture faced the dilemma that one would have to design a reproducible standard that could partition as many different forms as possible to build non-standard figurations.[20]

The dilemma of the non-standard standard moulds is found in Sebastiano Serlio's transcription of Alberti's codes into drawings. In the first book of his treatise, Serlio introduces a descriptive geometry to reproduce any contour and shape of a given object through a sequence of rectangles.[21]

For Serlio, the skill of the architect is to simplify the given world of shapes further until rectangles become squares. The reduction finally enables the representation of physical reality in architectural space using an additive assembly of either empty or full cubes. By building a parallel space of cubes, architecture can be partitioned into a reproducible code. In Serlio's case, architecture could be coded through a set of proportional ratios. However, from that moment on, stairs do not consist only of steps, and have to be built with invisible squares and cubes too.

Today, Serlio's architectural cubes are rendered obsolete by 3D printed sand. By shrinking parts to the size of a particle of dust, any imaginable shape can be approximated by adding one kind of part only. 3D printing offers a non-standard standard, and with this, five hundred years of architectural development comes to an end.

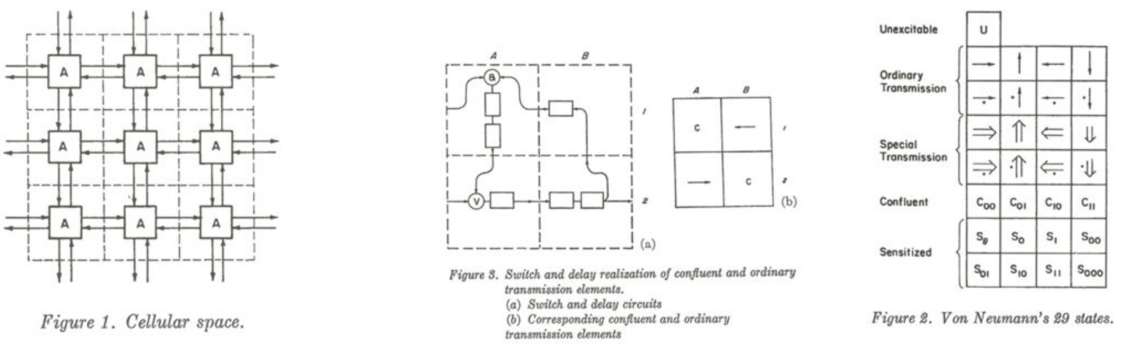


Figure 8 – Von Neumann's illustrations describing automata as a set of linkages between nodes. Image: Arthur W. Burks, 1969, public domain.

Replicating: A Spatial Practice of Representations

3D printing dissolved existing partitioning parts to particles and dust. A 3D-printer can not only print any shape but can also print at any place, at any time. The development of 3D printing was mainly driven by DIY hobbyists in the Open Source area. One of the pioneering projects here is the RepRap project, initiated by Adrian Bowyer.[22] RepRap is short for replicating rapid prototyping machine. The idea behind it is that if you can print any kind of objects, you can also print the parts of the machine itself. This breaks with the production methods of the Modern Age. Since the Renaissance, designers have crafted originals and used these to build a mould from those so that they can print as many copies as possible. This also explains the economic valuation of the original and why authorship is so vehemently protected in legal terms. Since Alberti's renunciation of drawings for a more accurate production of his original idea through textual encoding, the value of an architectural work consisted primarily in the coherence of a representation with a building: a play of virtual and real. Consequently, an original representation that cast a building was more valued than its physical presentation. Architecture design was oriented to reduce the amount of information needed to cast. This top-down compositional thinking of original and copy becomes obsolete with the idea of replication.

Since the invention of the printing press, the framework of how things are produced has not changed significantly. However, with a book press, you can press a book, but with a book, you can't press a book. Yet with a 3D printer, you can print a printer. A 3D printer does not print copies of an original, not even in endless variations, but replicates objects. The produced objects are not duplicates because they are not imprints that would be of lower quality. Printed objects are replicas, objects with the same, similar, or even additional characteristics as their replicator.

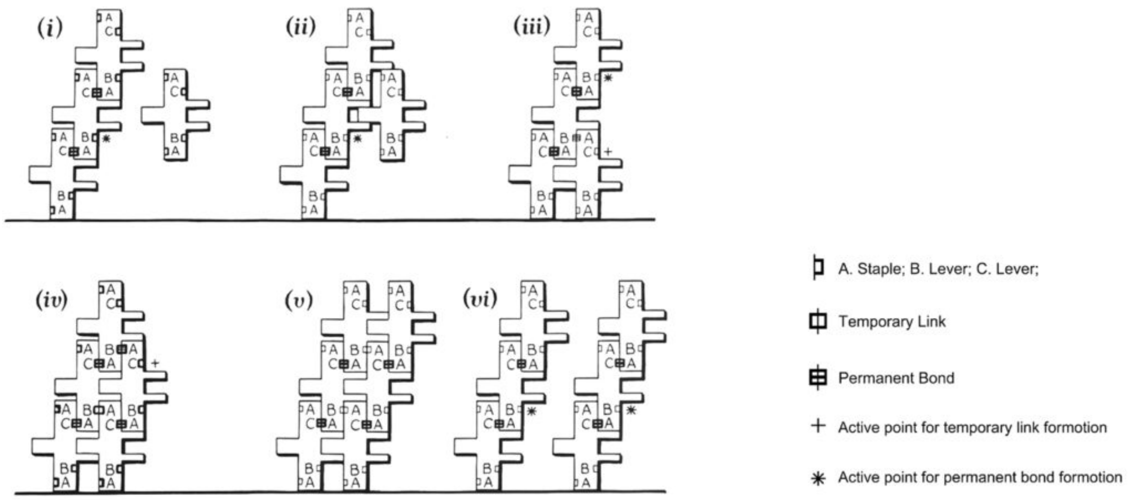


Figure 9 – Lionel R. Penrose, drawing for a physical implementation of a self-replicating chain of 3 units in length. Image: Photograph f40v, Galton Laboratory Archive, University College London, 1955.

A 3D printer is a groundbreaking digital object because it manifests the foundational principle of the digital – replication – on the scale of architecture. The autonomy of the digital is based not only on the difference between 0 and 1 but on the differences in their sequencing. In mathematics in the 1930s, the modernist project of a formal mimicry of reality collapsed through Godel's proof of the necessary incompleteness of all formal systems. Mathematicians then understood that perhaps far more precious knowledge could be gained if we could only learn to distance ourselves from its production. The circle of scientists around John von Neumann, who developed the basis of today's computation, departed from one of the smallest capabilities in biology: to reproduce. Bits, as a concatenation of simple building blocks and the integrated possibility of replication, made it possible, just by sequencing links, to build first logical operations, and connecting those programs to today's artificial networks.[23] Artificial intelligence is artificial but it is also alive intelligence.

To this day, computerialisation, not computation is at work in architecture. By pursuing the modern project of reconstructing the world as completely as possible, the digital project computerised a projective cast[24] in high resolution. Yet this was done without transferring the fundamental principles of interlinking and replication to the dimensions of the built space.

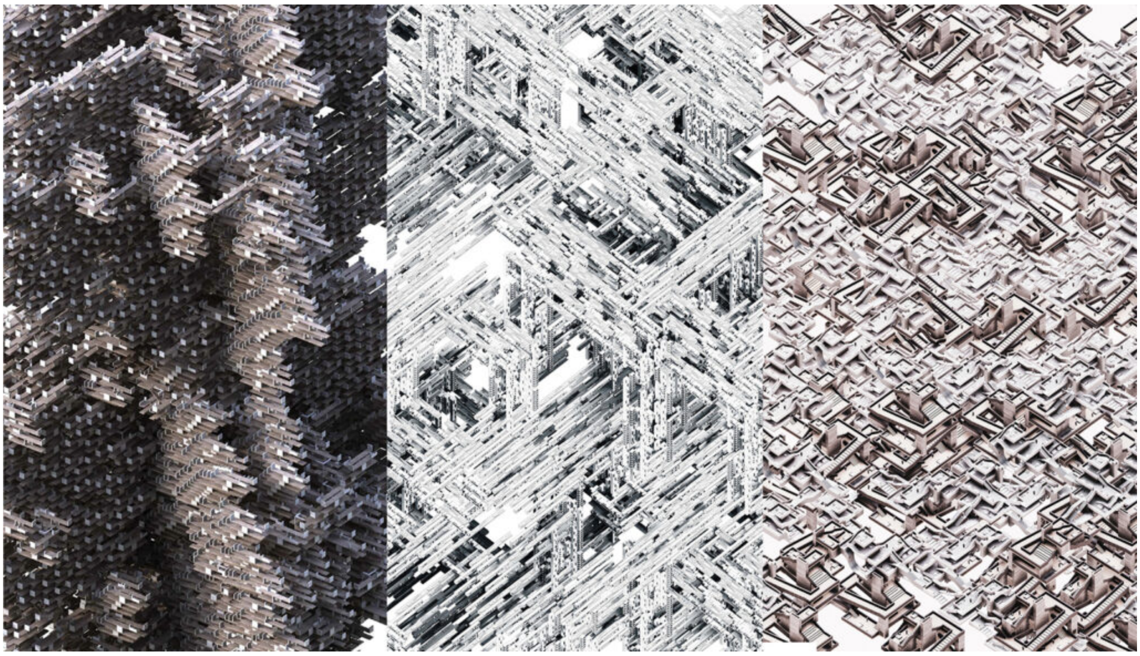


Figure 10 – (left to right) Mereologies: WanderYards, 2016, Genmao Li, Chen Chen, and Xixuan Wang, 2016; Enframes, Kexin Cao, Yue Jin, Qiming Li, 2017; iiOOOI, Sheghaf Abo Saleh, Hua Li, Chuwei Ye,

Yaonaijia Zhou, 2018 (right). Image(s): RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2016-2018.

From Partitioning to Partaking

The printing press depends on a mould to duplicate objects. The original mould was far more expensive to manufacture than its copies, so the casting of objects had to bundle available resources. This required high investments in order to start production, leading to an increasing centralisation of resources in order to scale the mass-fabrication of standard objects for production on an assembly line. Contrarily, digital objects do not need a mould. Self-replication provided by 3D printing means that resources do not have to be centralised. In this, digital production shifts to distributed manufacturing.[25]

Independent from any mould, digital objects as programs reproduce themselves seamlessly at zero marginal costs.[26] As computation progresses, a copy will then have less and less value. Books, music and films fill fewer and fewer shelves because it no longer has value to own a copy when they are ubiquitously available online. And the internet does not copy; it links. Although not fully yet integrated into its current TCP-IP protocol,[27] the basic premise of hyperlinking is that linked data adds value.[28] Links refer to new content, further readings, etc. With a close to infinite possibility to self-reproduce, the number of objects that can be delegated and repeated becomes meaningless. What then counts is hyper-, is the difference in kind between data, programs and, eventually, building parts. In his identification of the formal foundations of computation, the mathematician Nelson Goodman pointed out that beyond a specific performance of computation, difference, and thus value, can only be generated when a new part is added to the fusion of parts.[29] What is essential for machine intelligence is the dimensionality of its models, e.g., the number of its parts. Big data refers less to the amount of data, but more to the number of dimensions of data.[30]

Figure 11 – Enframes, 2017. Image: Kexin Cao, Yue Jin, Qiming Lim, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2017.

With increasing computation, architecture shifted from an aesthetic of smoothness that celebrated the mastership of an infinite number of building parts to roughness. Roughness demands to be thought (brute). The architecture historian Mario Carpo is right to frame this as nostalgic, as "digital brutalism".[31] Similar to brutalism that wanted to stimulate thought, digital roughness aims to extend spatial computability, the capability to extend thinking, and the architecture of a computational hyper-dimensionality. Automated intelligent machines can accomplish singular goals but are alien to common reasoning. Limited around a ratio of a reality, a dimension, a filter, or a perspective, machines obtain partial realities only. Taking them whole excludes those who are not yet included and that which can't be divided: it is the absolute of being human(e).

A whole economy evolved from the partial particularity of automated assets ahead of the architectural discipline. It would be a mistake to understand the 'sharing' of the sharing economy as having something "in common". On the contrary, computational "sharing" does not partition a common use, but enables access to multiple, complementary value systems in parallel.

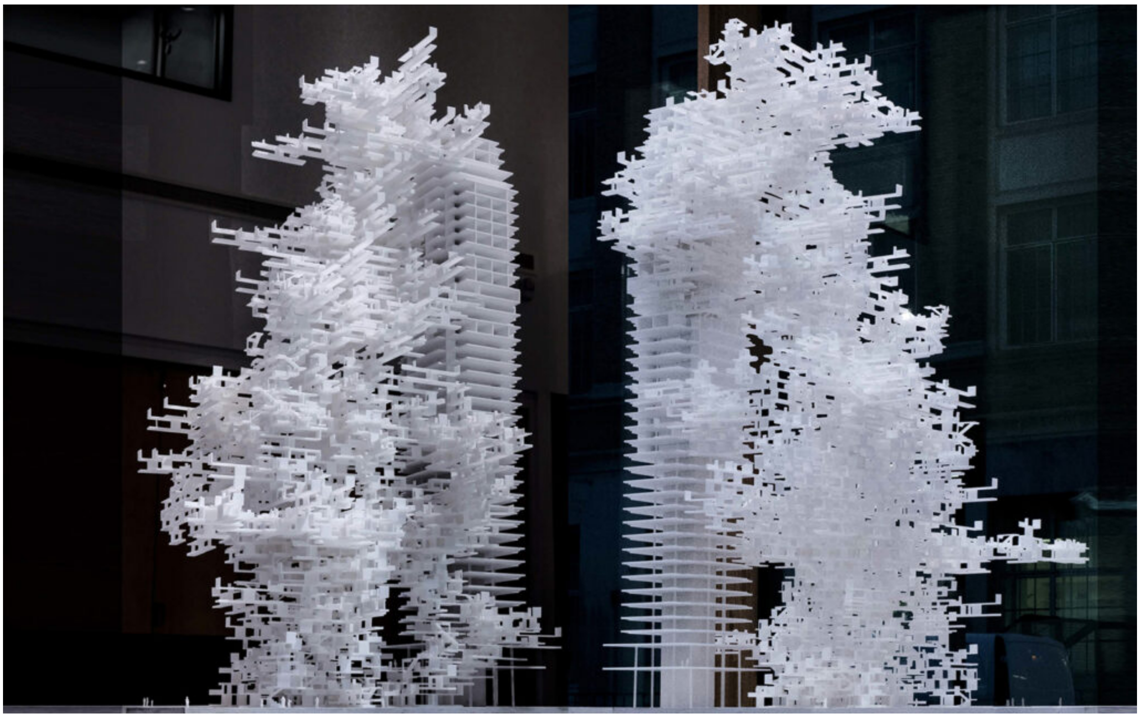


Figure 12 – Physical model, WanderYards, 2017. Image: Genmao Li, Chen Chen and Xixuan Wang, RC8, MArch Architecture Design, The Bartlett School of Architecture, UCL, 2017.

Cities now behave more and more like computers. Buildings are increasingly automated. They use fewer materials and can be built in a shorter time, at lower costs. More buildings are being built than ever before, but fewer people can afford to live in them. The current housing crisis has unveiled that buildings no longer necessarily need to house humans or objects. Smart homes can optimise material, airflow, temperature or profit, but they are blind to the trivial.

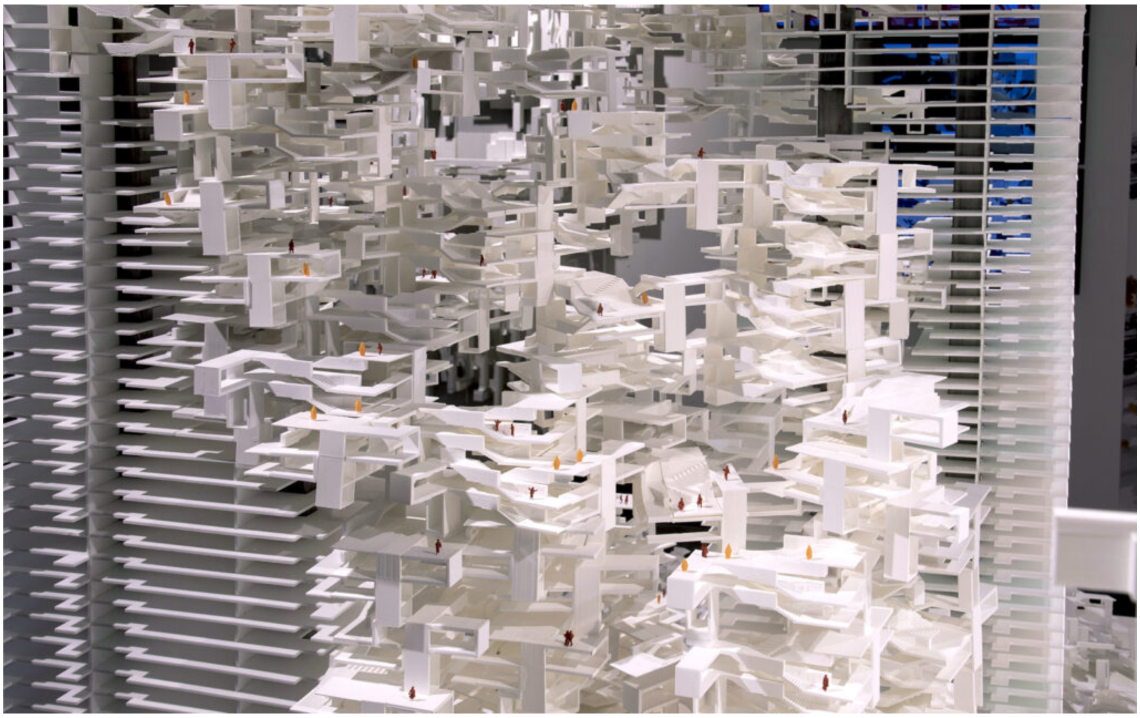


Figure 13 – Physical model, Slabrose, 2019. Image: Dongxin Mei, Zhiyuan Wan, Peiwen Zhan, and Chi Zhou, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

It is a mistake to compute buildings as though they are repositories or enclosures, no matter how fine-grain their resolution is. The value of a building is no longer derived only from the amount of rent for a slot of space, but from its capacities to partake with. By this, the core function of a building changes from inhabitation to participation. Buildings do not anymore frame and contain: they bind, blend, bond, brace, catch, chain, chunk, clamp, clasp, cleave, clench, clinch, clutch, cohere, combine, compose, connect, embrace, fasten, federate, fix, flap, fuse, glue, grip, gum, handle, hold, hook, hug, integrate, interlace, interlock, intermingle, interweave, involve, jam, join, keep, kink, lap, lock, mat, merge, mesh, mingle, overlay, palm, perplex, shingle, stick, stitch, tangle, tie, unit, weld, wield, and wring.

In daily practice, BIM models do not highlight resolution but linkages, integration and collaboration. With further computation, distributed manufacturing, automated design, smart contracts and distributed ledgers, building parts will literally compute the Internet of Things and eventually our built environment, peer-to-peer, or better, part-to-part – via the distributive relationships between their parts. For the Internet of Things, what else should be its hubs besides buildings? Part-to-part habitats can shape values through an ecology of linkages, through a forest of participatory capacities. So, what if we can participate in the capacities of a house? What if we no longer have to place every brick, if we no longer have to delegate structures, but rather let parts follow their paths and take their own decisions, and let them participate amongst us together in architecture?

Figure 14 – Interior view of physical model, NPoche, 2018. Image: Silu Meng, Ruohan Xu, and Qianying Zhou. RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2018.

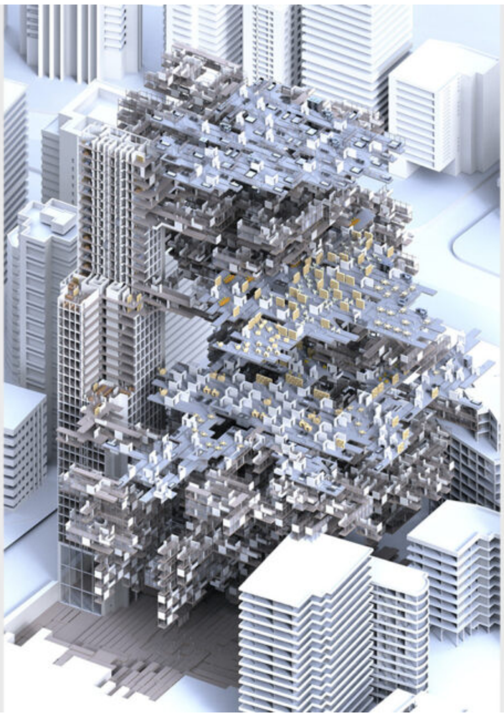
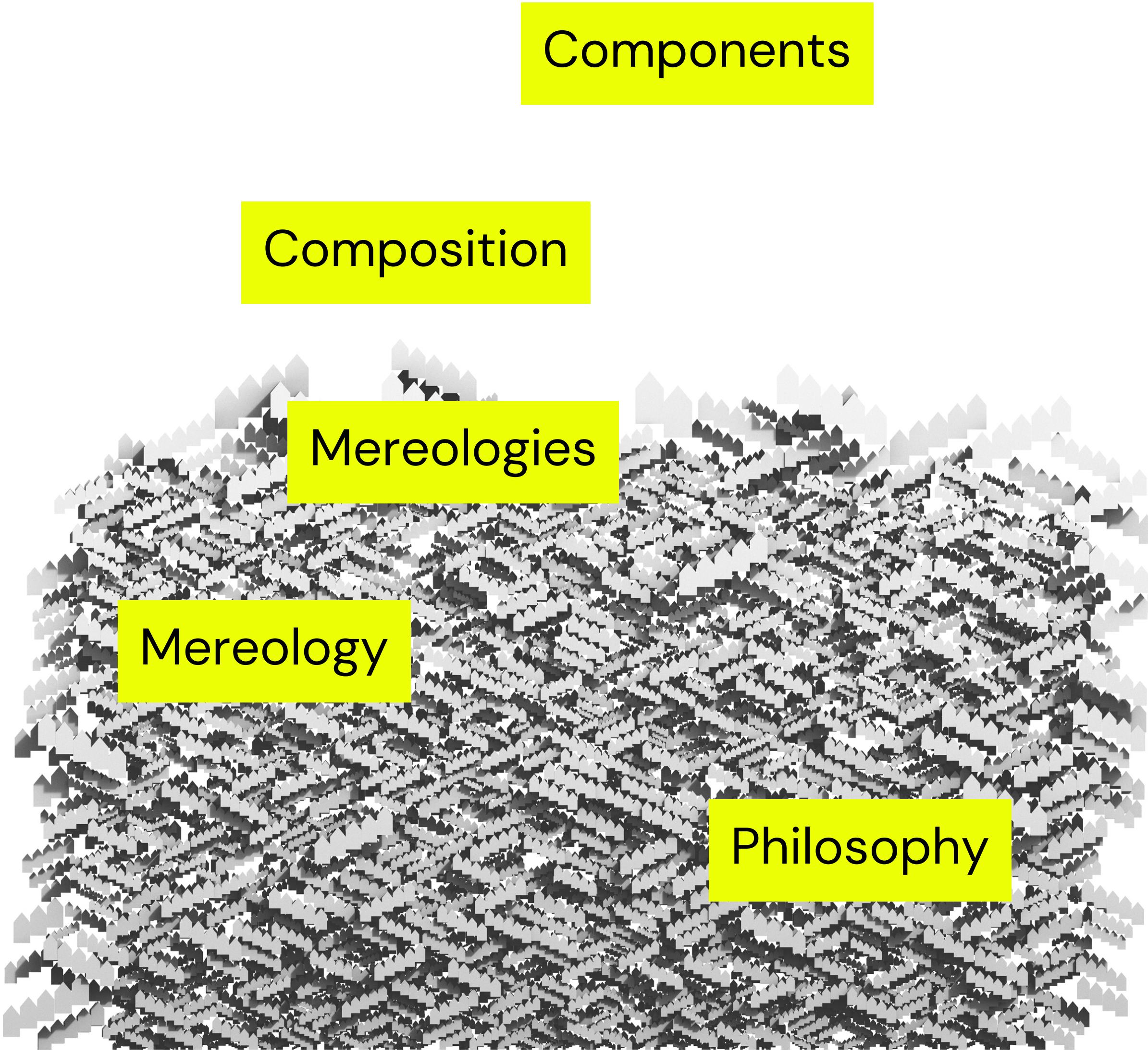


Figure 15 – Seggregational section, WanderYards, 2017. Image: Genmao Li, Chen Chen and Xixuan Wang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2017.

Article 4 : Mereology and Structure



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In this short paper I illustrate what is mereology for philosophers, and which reasons lead philosophers to discuss mereological theses and disagree one with another about them. I will focus in particular on the role of structure in mereology and propose a rather simple account of what structure is from the viewpoint of mereology. As we are going to see, many philosophical controversies in mereology concern the issue of whether mereology should account for structure or not, and which role (if any) structure plays in mereology. I will also present some examples of philosophical controversies about mereological principles, and of the reasons which might be brought for choosing one side or the other in these controversies.

An additional purpose of the paper is to suggest that structure is a broad topic of common concern between architecture and philosophical mereology. In their discussions about structure, mereologists do often resort to examples involving buildings and villages. These examples – I am going to use some of them in what follows – are extremely simple, to the point of *naïveté*. The frequent usage of these examples might depend on the rough intuition that there are indeed some connections between mereology and architecture, and the concept of structure might be the link between them.

What Is Mereology About?

Let us begin by asking what is mereology. Mereology is the theory of two (mutually related) relations: parthood and composition. Parthood is a one-one relation between a part and a whole. These are some instances of parthood:

my left hand is part of my body;

Portugal is part of Europe;

an atom of oxygen is part of a molecule of water;

a handle is part of a door;

the word ‘salad’ is part of the sentence ‘I eat a salad’.

The other relation which, together with parthood, is the subject matter of mereology is composition, a many-one relation. Composition indeed connects many entities (the components) to a single entity (the composed entity). Consider a rather simplistic house with a base, four outer walls, a roof and nothing else. The base, the four walls and the roof compose the house. Another example is the following: the Netherlands, Belgium and Luxembourg compose Benelux.

Composition is definable in terms of parthood. The composed entity is expected to include all the components as parts and not to include anything extraneous to the components. Also the latter feature of the composed entity can be expressed in terms of parthood, namely by requiring that every part of the composed entity has at least a part in common with at least one of the components.
In order to express the resulting definition of composition in terms of parthood we can first define the relation of overlap, which holds between two entities if and only if they have at least a part in common (P is the relation of parthood; $\circ$ is the defined relation of overlap):

Overlap: $x \circ y \equiv_{def} \exists z\,(z\,P\,x \wedge z\,P\,y)$

Now, composition can be defined in terms of parthood and overlap (which has in turn been defined in terms of parthood above) as follows (C is the relation of composition; *xx* is a plural variable for the components; $\prec$ is the relation of *being one of*):

Composition: $xx\,C\,y \equiv_{def} \forall z\,(z \prec xx \rightarrow z\,P\,y) \wedge \forall z\,(z\,P\,y \rightarrow \exists w\,(w \prec xx \wedge z \circ w))$

According to this definition, some entities *xx* compose one entity *y* if and only if every entity *z* that is one of *xx* is also part of *y* and every entity *z* that is part of *y* is such that there is an entity *w* that is one of *xx* and overlaps *z*.

What do mereologists say about parthood and composition? They attribute some features to these relations. The attributed features are generally expected to be *formal* or *topic-neutral*, in the sense that the features are not expected to depend on which kinds of entities are part of one another or compose one another. For example, the features of parthood and composition are expected by mereologists to be independent of whether we are considering the parts of a human body, the parts of a chemical molecule, or the parts of a town. Mereology is also formal in a more general sense, inasmuch as mereology never attempts to identify the parts of something or to establish what composes what: it is not the expected duty of mereology to establish what are the parts of a car, or of a building, or what composes a sentence.

Mereological principles consist in attributions of some formal features to parthood and composition. Let us consider some examples of mereological principles and of formal features which these principles attribute to parthood and composition. In considering these examples, it is important to keep in mind that every mereological principle (any attribution of formal features to parthood and composition) is controversial, including the following examples. It can also be controversial whether the principles at stake are really formal: given a candidate principle, it might be objected that it holds when parthood is instantiated by, say, buildings, while it fails when parthood is instantiated by animal organisms.

A mereological principle about parthood defended by many philosophers is for example that parthood is a transitive relation (transitivity is the formal feature which this principle attributes to parthood): if *a* is part of *b* and *b* is part of *c*, then *a* is part of *c*. Here are three more or less controversial instances of transitivity (involving various kinds of entities, in coherence with the expected topic-neutrality of mereological principles):

if a handle is part of a door and the door is part of a building, then the handle is part of the building;

if my left hand is part of my left arm and my left arm is part of my body, then my left hand is part of my body;

if an MP is part of the Italian Parliament and the Italian Parliament is part of the Inter-Parliamentary Association, then the MP is part of the Inter-Parliamentary Association.

Principles about parthood also concern the problem of whether the chains of parthood terminate or not. Do the chains of parthood terminate downwards? Does everything have a part that is different from itself no matter how deep you go down? Or is there a bottom layer of mereological simples (i.e. entities without further parts)? In the other direction, do the chains of parthood terminate upwards? Is everything part of something different from itself? Or is there a top layer, the mereological universe (i.e. an entity such that everything is part of it, and it is part of nothing different from itself)? Mereological principles can dictate an answer to these questions.

These principles can be applied to matters of potential architectural or urbanistic concern. As regards downward termination, a problem of potential architectural concern is whether there is a bottom layer of parts of a building (say: the layer of bricks, or the layer of the smallest pieces which are *visible* to the human eye). As regards upward termination, a problem of potential urbanistic concern is whether there is a top layer of entities, over which entities stop being interesting for urbanists and are at best interesting for other kinds of scholars, such as geographists.

Other principles concern composition (the other relation, which – together with parthood – is the subject matter of mereology). The principles about composition mainly provide existence conditions and identity conditions for composed entities. Existence and identity are in general two pivotal concepts in metaphysics, i.e. in the wider branch of philosophy to which mereology belongs. As far as composition is concerned, mereology asks whether, given some entities, there *exists* something which they compose (in answering this question, mereologists provide existence conditions for composed entities), and whether there may exist two or more entities composed by the same entities (in answering this latter question, mereologists provide identity conditions for composed entities).

Thus, given some components, how many things do they compose? Consider Barack Obama's nose, my left shoe and the Great Pyramid of Giza. Do they compose anything? Is there a spatially scattered object (a bit in Washington, a bit here, a bit in Egypt) they compose?

Consider instead a building entirely made of bricks. Those bricks compose that building. Do the bricks compose only the building? Or do they compose also a different, less structured entity, which we might dub 'heap of bricks'? Suppose that the building collapses: after the collapse – one might say – the building stops existing, while the heap of bricks continues existing. How can this happen, if they are identical, i.e. if the bricks compose only one entity? A single entity cannot both continue existing and stop existing.

The following are two examples of two rather popular (albeit controversial) mereological principles about composition (their usual label is indicated in the parenthesis):

given some entities – no matter how sparse and heterogeneous they are – there is *at least* an entity composed by them (Unrestricted Composition);

given some entities, there is *at most* an entity composed by them (Uniqueness of Composition).

Unrestricted Composition provides existence conditions for composed entities, while Uniqueness of Composition provides identity conditions for composed entities.

The Role of Structure in Mereology

In the above example of the brick building and of the heap of bricks, we have seen how the temptation arises to distinguish wholes according to their being structured or non-structured, or according to their being structured in different ways. In order to appreciate the role of structure in mereology, it is very important not to misidentify the *subject matter* of the philosophical controversies about this kind of example.

Indeed, no mereologist doubts that, in order to compose a building, the bricks have to be in some mutual relations and that, more in general, not any heap of bricks is a building. There is no interesting philosophical controversy on the fact that the parts of many composed entities are arranged or structured in a certain way.

The problem mereology is concerned with is different: does structure have any impact on the *existence* and *identity* of composed entities? Do some things need to be structured in a certain way (e.g. in a building-like way, or in a car-like way, or in a person-like way, or in a mountain-likeway) in order to compose something? There is obviously a differencebetween the parts of a car on the one hand, and Barack Obama's nose,my left shoe and the Great Pyramid of Giza on the other. The difference isthat the parts of a car are in certain mutual relations and have certaindesignated functional roles. The relations among the parts of a car andtheir functional roles are constrained by the nature of cars in general, andby the project of that specific car model. The mutual relations amongparts and the roles of the parts are roughly what structure consists in.

To repeat: nobody doubts that the parts of a car have a kind of structure which, by contrast, disparate, sparse entities lack. Mereology is not about this. The mereological problem at stake is whether, on the basis of this difference between the parts of a car on the one hand, and Barack Obama's nose, my left shoe and the Great Pyramid of Giza on the other, we should conclude that only the parts of a car compose something, while Barack Obama's nose, my left shoe and the Great Pyramid of Giza do not compose anything. If this were the case, then, in contrast with the above principle of Unrestricted Composition, it would not be true that, given some entities – no matter how disparate and sparse they are – there exists something they compose: there would be nothing which Barack Obama's nose, my left shoe and the Great Pyramid of Giza compose.

Unrestricted Composition is a mereological principle according to which structures have no bearing on the existence conditions for composed entities. According to Unrestricted Composition, composed entities exist irrespective of whether and how their components are structured.

Another mereological problem concerning structure is: does structure have any bearing on the identity conditions of composed entities? According to Uniqueness of Composition, given some entities there is at most one entity composed by them. Thus, there cannot be two different entities composed by the same entities. This entails that two composed entities cannot have exactly the same parts. If the composed entities are different, then they have a different part, and this different part is their difference maker. The fact that these parts are in different mutual relations and have different roles is not an admissible difference maker for composed entities. If Uniqueness of Composition is true, then the identity conditions for composed entities countenance only their parts, and not their structure. Thus, both Unrestricted Composition (for what concerns the existence conditions for composed entities) and Uniqueness of Composition (for what concerns the identity conditions for composed entities) exhibit a kind of deliberate blindness to structure.

Principles of Structure Obliteration

Before considering how it is possible to argue in favour or against this blindness to structure, it is useful to be a bit more precise on how structure is construed in this context. A theory of parthood and composition can countenance or obliterate various aspects of structure. This depends on whether, in a certain theory of parthood, certain principles of structure obliteration hold or not. We will consider four principles of structure obliteration.[1] These principles are interesting because they are of help in distinguishing various *aspects* of structure. These aspects of structure are obliterated in the identity conditions for composed entities, if the respective obliteration principle holds. They are by contrast countenanced in the identity conditions for composed entities, if the respective principle fails.

The first principle is Absorption and claims that the repetition of parts is not a difference maker for composed entities. If Absorption is true, then the repetition of parts has no impact on the identity conditions for composed entities. Absorption can be formalised as follows (▯ is an operation of composition, whose inputs are the components and whose output is the composed entity; the formula expresses the fact that the multiple occurrences of the inputs – expressed by the multiple occurrences of the variables *x* and *y* in the left part of the formula – make no difference for the identity conditions of the output):

Absorption: $\Sigma (\ldots, x, x, \ldots, y, y, \ldots) = \Sigma (\ldots, x, \ldots, y, \ldots)$

The second and the third principles are Collapse and Levelling and jointly claim that the stratification and the groupings of parts at different levels are not difference makers for composed entities (i.e. they have no impact on the identity conditions for composed entities).

Collapse: $\Sigma (x) = x$

Levelling: $\Sigma (\ldots, \Sigma(x, y, z, \ldots), \ldots, \Sigma (u, v, w, \ldots), \ldots) = \Sigma (\ldots, x, y, z, \ldots, \ldots, u, v, w, \ldots, \ldots)$

The fourth principle is Permutation and claims that the *order* of the parts is not a difference maker for composed entities (i.e. it has no impact on the identity conditions for composed entities).

Permutation: $\Sigma (\ldots, x, \ldots, y, \ldots, z, \ldots) = \Sigma (\ldots, y, \ldots, z, \ldots, x, \ldots)$

This approach manages to differentiate various theories of parthood, according to their degree of blindness with respect to structure. What is usually called (for historical reasons) Classical Mereology abides by all the above four principles of structure obliteration and is, as a result, deliberately blind with respect to the repetition, to the stratification, to the groupings at different levels and to the order of the components in a composed entity. Only the parts matter for the identity conditions of composed entities, according to Classical Mereology. By contrast, the ways in which the parts are arranged/structured (e.g. repeated, stratified, grouped or ordered) do not matter.

It is noteworthy that the four principles of structure obliteration are mutually independent. If you adopt a Non-Classical Mereology, you are not thereby forced to reject all the four principles as a single package. You can reject one or more of them, while keeping the others. In so doing, you sometimes end up adopting a theory which is no less well-established than Classical Mereology. For example, suppose that you think that the stratification and groupings at various levels of parts matter for the identity conditions of composed entities, while their order and repetition do not matter. What you obtain is Set Theory, a well-established theory, with a pivotal role in the foundations of mathematics.

Controversies in Mereology (and How to Argue About Them)

How should we argue about the formal features of parthood and composition? What reasons can be brought in favour of or against the mereological principles which attribute formal features to parthood and composition? And what reasons can – in particular – be brought in favour of or against the principles we have introduced above, such as Transitivity of Parthood, Unrestricted Composition, Uniqueness of Composition and the four principles of structure obliteration?

Mereologists mainly proceed either by analysing and assessing alleged *counterexamples* to the mereological principles, or by analysing and assessing a priori arguments in support of or against them. As far as counterexamples are concerned, let us focus on Uniqueness of Composition and on its radical blindness to structure (i.e. – as we have seen in § 3 – blindness to repetition, stratification, groupings at different levels and order of components in a composed entity). One might be tempted to dismiss Uniqueness of Composition rather quickly, on the basis of the fact that some prima facie unavoidable counterexamples might seem fatal to it.

Consider the components of the sentence 'Gina loves Mario': the words 'Gina', 'loves' and 'Mario'. The same components can also form the sentence 'Mario loves Gina'. 'Gina loves Mario' and 'Mario loves Gina' might seem two composed entities with the same components, in contrast with Uniqueness of Composition. The order of words (an aspect of structure, which belongs to the subject matter of syntax in linguistics) in sentences seems to matter for the identity conditions of sentences, in contrast with Uniqueness of Composition and with Permutation.

Consider also a very small village, composed by a square, two streets and four buildings. It seems prima facie plain that Uniqueness of Composition fails for those components: the disposition of the streets with respect to the square, and the location of the buildings with respect to those of the square and of the streets (in general: the way in which the components of the village are arranged) would seem to matter for the identity of the village.

However, the evaluation of these alleged counterexamples is not as easy as it seems, and Uniqueness of Composition should not be dismissed so quickly. Why? Because whether two composed entities (two sentences, two small villages) can be different while having the same parts and whether they can – as a consequence – be different only in virtue of their structure depends on a controversial identification of the entities at stake.

In the case of the sentence, it depends on whether the entities at stake are linguistic tokens or types. Consider only single concrete tokens or inscriptions of 'Mario', 'loves' and 'Gina': sequences of sounds, stains of ink or groups of pixels on a screen. These concrete tokens are always in a single, specific order. Some of these inscriptions are ordered in a way such that 'Mario' is the first inscription (counting from the left) and 'Gina' is the last inscription (this is the case of the word inscriptions in 'Mario loves Gina'). Others of these inscriptions are ordered in a way such that 'Gina' is the first inscription (counting from the left) and 'Mario' is the last inscription (this is the case of the word inscriptions in 'Gina loves Mario'). It never happens that the same inscriptions are arranged in two ways and thereby compose two different wholes. The initial impression that it is clear that two sentences can be different simply due to the arrangement of their parts (even if they have exactly the same parts) depends on seeing words not as tokens but as abstract word types, which occur in many different sentence types.

Consider also the case of the small village. Given a specific small village, at a specific time, the square, the two streets and the four buildings are arranged in a single way (they have a single structure). There are not two small villages composed by that square, those streets and those buildings at that time.

These considerations about the sentence and the small village can, as a matter of fact, be generalised. Whenever we are tempted to dismiss those principles of Classical Mereology which express its deliberate blindness to structure, it turns out that the temptation depends on a controversial characterisation of the involved entities.[2]

Please note that the philosophers objecting to Uniqueness of Composition might refine their counterexamples, and the defenders of Uniqueness of Composition might refine their analysis in order to deal with these counterexamples: the purpose of the above analysis is not to resolve the philosophical disputes about the role of structure in mereology in favour of blindness to structure, but to exemplify the way in which philosophers argue one with another about mereology and structure. The exemplifications are also meant to suggest that these controversies are unlikely to be *easily* solvable by adducing counterexamples: the analysis of these counterexamples is often arduous and depends on controversial assumptions.

Finally, I would like to discuss an example of the second main way of arguing about mereological principles, the one which involves general, a priori arguments in support of or against mereological principles. Let us focus in this case on Unrestricted Composition. Suppose that you deny Unrestricted Composition. This denial will be based on the intuition that there is a patent difference between – say – the parts of a car on the one hand, and Barack Obama's nose, my left shoe and the Great Pyramid of Giza on the other. What does this difference consist in? In order to obtain an alternative to Unrestricted Composition, this difference should correspond to a general condition which a plurality of entities should satisfy in order to have a fusion.

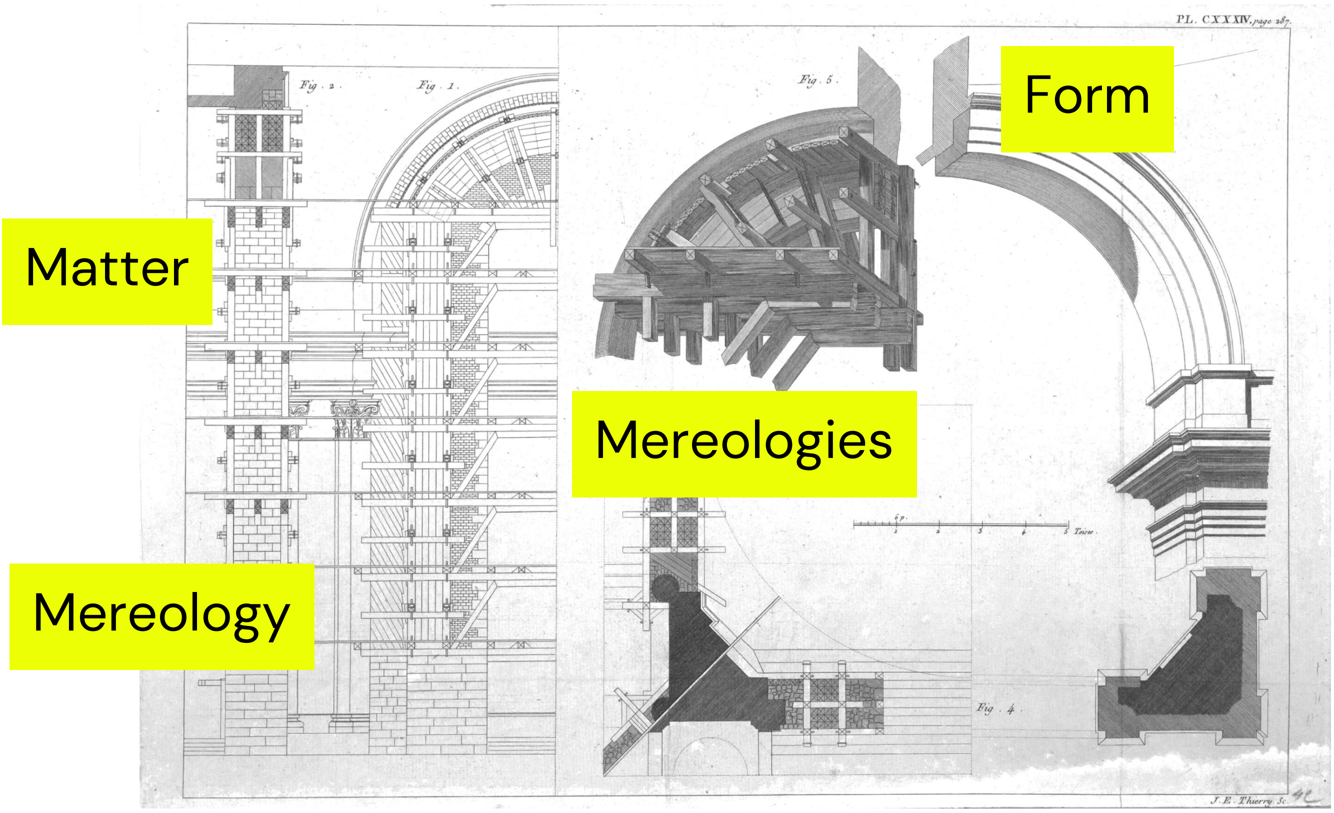
We might try to extract this general condition from the examples, e.g. by observing that the parts of a car are spatially close one to another, while Barack Obama's nose, my left shoe and the Great Pyramid of Giza are not; or by observing that there are causal links among the parts of a car (e.g. a movement in the steering causes a movement in its anterior wheels), while Barack Obama's nose, my left shoe and the Great Pyramid of Giza are in no direct causal connection. On this basis, one might propose the following criteria for the restriction of composition: only mutually close entities compose something; only entities which move together (or act together) compose something. However, these criteria are unavoidably vague. There is no such thing as being definitely close in space or as being definitely causally connected. Every two parts of the universe are at some distance and have some kind of more or less remote causal connection.

How is it possible to fix a threshold, i.e. a minimal degree of proximity orof causal connectedness? The threshold should be such that: entitiesabove that threshold compose something; entities below that thresholddo not compose anything. For example, we should determine once andfor all at which maximum distance some buildings should be in order tocontribute to compose a certain town, instead of belonging to twodifferent towns. Any such threshold would be arbitrary, and would riskmaking arbitrary our existence claims about composed entities (such astowns) as well.

A famous argument in support of Unrestricted Composition is based on the thesis that existence claims cannot be either vague or arbitrary. This means that no compelling motivation for restricting composition can be satisfied, and that, as a consequence, composition cannot be restricted. Thus, composition would be unrestricted.

The general idea behind this famous argument for Unrestricted Composition (of which I have presented a simplified version)[3] is that existence conditions for composed entities should not be constrained by structural considerations about the mutual unity of parts. Why? Because it is arbitrary to delimit the domain of what is unitary. Every plurality of entity can be seen as unitary (or as non-unitary) according to certain criteria and/or from a certain standpoint. This is a general motivation why classical mereology is deliberately blind to structure: because the attribution of roles to structure risks introducing arbitrary and hardly justifiable thresholds. Thus, also, when mereologists proceed by analysing and assessing *a priori* arguments – as much as when they proceed by analysing and assessing counterexamples, as we have seen above – the problem whether structure has any role in mereology is pivotal, and has no easy solution.

Article 5 : Matter versus Parts: The Immaterialist Basis of Architectural Part-Thinking



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“Digital Matter”; “Intelligent Matter”’; “Behavioural Matter”; “Informed Matter”; “Living Matter”, “Feeling Matter”; “Vibrant Matter”; “Mediated Matter”; “Responsive Matter”; “Robotic Matter”; “Self-Organised Matter”; “Ecological Matter”; “Programmable Matter”; “Active Matter”; “Energetic Matter”. There is no term enjoying better reputation in today’s experimental architectural discourse. Gently provided by a myriad of studios hosted in pioneer universities around the world, the previous expressions illustrate the redemption of a notion that has traditionally been dazzled by form’s radiance. After centuries of irrelevance, “Matter” has recently become a decisive term; it illuminates not just the field of experimental architecture, but the whole spectrum of our cultural landscape: several streams in philosophy, art and science have vigorously embraced it, operating under the gravitational field of its holistic and non-binary constitution.

However, another Copernican Revolution is flipping today’s experimental academic architecture from a different flank. In parallel to matter’s redemption and after the labyrinthic *continuums* characteristic of the ’90s, discreteness claims to be the core of a new formal paradigm. Beside its Promethean vocation and renewed cosmetics, the discrete design model restores the relevance of a term that traditionally has been fundamental in architecture: the notion of part. However, in opposition to previous architectural modulations, part’s current celebration is traversed by a Faustian desire for spatial and ontological agency, which severely precludes any reverential servitude to its whole.

The singular coincidence of matter's revival on the one side and the discrete turn on the other opens a debate in relation to its possible conflicts and compatibilities in the field of experimental architecture. In this essay, the discussion gravitates around one single statement: the impossibility of a materialist architectural part-thinking. The argument unfolds by approaching a set of questions and analysing the consequences of its possible answers: how matter's revival contributesto architectural part thinking? Is matter's revival a mere importation offormal attributes? Which are the requirements for a radical part-thinkingin architecture? Is matter well equipped for this endeavour? In short, arethe notions of matter and part-thinking compatible in an architectural environment?

Pre-Socratic philosophy defined matter as a formless primordial substratum that constitutes all physical beings. Its irrevocable condition is that of being "ultimate": matter lies in the depth of reality as more fundamental than any definite thing.[1] Under this umbrella, pre-Socratic philosophy ramifies in two branches: the first one associates matter with continuity, the second one associates matter with discretism.

Anaximander is the standard-bearer of the first type: the world is pre-individual in character and it is fueled by the *apeiron*, a continuum to which all specific structures can be reduced. We can find traces of this sort of materialism in Gilles Deleuze's "plane of immanence", Bruno Latour's "plasma", or Jane Bennett's "vibrant matter". Democritus is the figurehead of the second type: the world is composed by sets of atoms, that is, privileged discrete physical elements whose distinct combinations constitute the specific entities that populate the world. Resonances of this sort of materialism can be found in the "quanta" of contemporaneous quantum mechanics. Independently of their continuous or discrete nature, both types of materialisms are underpinned by an ontological assumption: the identification of matter with an ultimate cosmic whole. To this purpose, matter's generic condition is decisive: its lack of specificity is precisely what grants matter the status of "ultimate", which logically and chronologically precedes distinction.

Architecture's conceptualisation of matter has not been impermeable to these philosophical discourses. In spite of the negative reputation that the Aristotelian hylomorphism projected on matter by converting it into the reverential servant of form – absent in pre-Socrátic philosophy and being introduced, in different ways, by Plato and Aristotle – in the last centuries many architectural projects opposed this status quo by capitalising on both types of materialism. Since the Enlightenment and still under form's reign, matter has been recovering its pre-Socratic positive character by absorbing all the attributes traditionally ascribed to form. However, it also operated a conceptual replacement that is crucial in this discussion: matter moved from a marginal role in a hylomorphic dualist scheme to the solitary leadership of an ultimate holism. As we will see below, in architecture and particularly since the Enlightenment, matter's relevance has been gradually recovered through its association with two key concepts: truthfulness, emphasised by authors of the late 18th and 19th century such as Viollet le Duc or Gottfried Semper, and vitalism, underlined by authors of the 19th century and early 20th century such as Henry Bergson or Henri Focillon.[2] Today this process has culminated with Eric Sadin's notion of *antrobology*, that is, the "increasingly dense intertwining between organic bodies and 'immaterial elfs' (digital codes), that sketches a complex and singular composition which is determined to evolve continually, contributing to the instauration of a condition which is inextricably mixed 'human/artificial."[3]

In this technological framework and through the notions of information, platform and performance, matter's traditional attributes have been replaced by those of form. Despite keeping the term "matter" as a signifier, the disorder, passivity and homogeneity that conventionally characterised its significance have been substituted by form's structure, activity and heterogeneity. However, one crucial feature that is absent in the dualistic hylomorphic model has been reintroduced: matter's pre-Socratic condition of being ultimate.

This incorporation is decisive when it comes to architectural part-thinking. In spite of the great popularity that matter has achieved within contemporary experimental architecture, its ultimate condition precludes any engagement with architectural part-thinking: either as a single continuous field or as a set of discrete particles, matter exalts a single holistic medium that lies at the core of reality, that is, a fundamental substrata (whole) in which all specific entities (parts) can be reduced. In a context in which designers use the power of today's super computation to notate the inherent discreteness of reality instead of reducing it to simplified mathematical formulas,[4] or field, reality's approach through generic and Euclidean points (particles) rather than distinct elements (parts) constitutes an unnecessary process of reduction that dissolves part's autonomy.

This essay develops this argument in two steps. First, it states that the current culmination of matter's revival process in experimental architecture is, paradoxically, nothing but the exaltation of form; under the same signifier, matter's signification has been replaced by form's signification: all attributes that in the hylomorphic model were associated with the latter have now moved to the former, converting matter's signifier into just another term to conjure up the significance of form. However, there is a crucial pre-Socratic introduction in relation to the hylomorphic model: matter is now understood as being also the ultimate single substance of reality, and not just the compliant serf of another element (form). This holistic vocation can be traced in contemporaneous experimental architecture in parallel to matter's pre-Socratic distinction between a continuous field (Anaximander's apeiron) and a discrete set of particles (Democritus's atoms).

Second, this essay argues that current materialism, in any of its twofold registers, is incompatible with architectural part-thinking. The argument first identifies and evaluates three groups of architectural parts (topological, corpuscular and ecological) in the current experimental architectural landscape and second proposes a fourth speculative architectural part based on the notion of limit. If the idea of part demands a certain degree of autonomy from the whole, it cannot be reducible to any ultimate substrata, and therefore matter's holistic condition becomes problematic both in its continuous and discrete register. However, the latter demands particular attention: discretism's spatial countability might lead us to confuse the notion of particle with that of part. However, they significantly differ: while particles are discrete only from a mathematical perspective (countable), parts are discrete as well from an ontological perspective (distinct). Parts require at least both dimensions of discreteness in order to be considered autonomous from any exteriority, while simultaneously keeping its capacity to participate in it.

Architectural part-thinking demands then a radical formal approach. It requires a notion of form that operates at every level of scale, that is, an immaterialist model that recursively avoids any continuous (field) or discrete (particle) ultimate substrata in which parts could be reduced. This pan-formalism would imply then the presence of a form beyond any given form, understanding the term "form" as an autonomous spatio-temporal structure.

Matter's Recovery Process in Architecture: Truthfulness, Vitalism and Antrobology

Since Ancient Greece, architecture has interpreted the notion of matter through Aristotle's hylomorphic scheme: matter is a disordered, passive and homogenous mass (matter) in attendance for a structured, active and heterogeneous pattern (form). According to this framework the architect is constituted as a demiurge: they operate from a transcendent plane in order to inform matter, that is, in order to structure its constitution through a defined pattern. However, since the Enlightenment, matter's signifier has gradually replaced its signification with that of form through three concatenated strategies: truthfulness, vitalism and antrobology.

The concept of truthfulness in architecture should be read in opposition to the idealism of authors like Alberti or Palladio. In his *De Re-aedificatoria* , Alberti claimed that "architecture is not about artisan techniques but about 'cose mentale'."[5] What concerned him was not material attributes such as colour or texture, but the geometrical proportions of the forms that he produced with matter. This statement becomes evident in his façade for the Malatesta Temple in 1450.

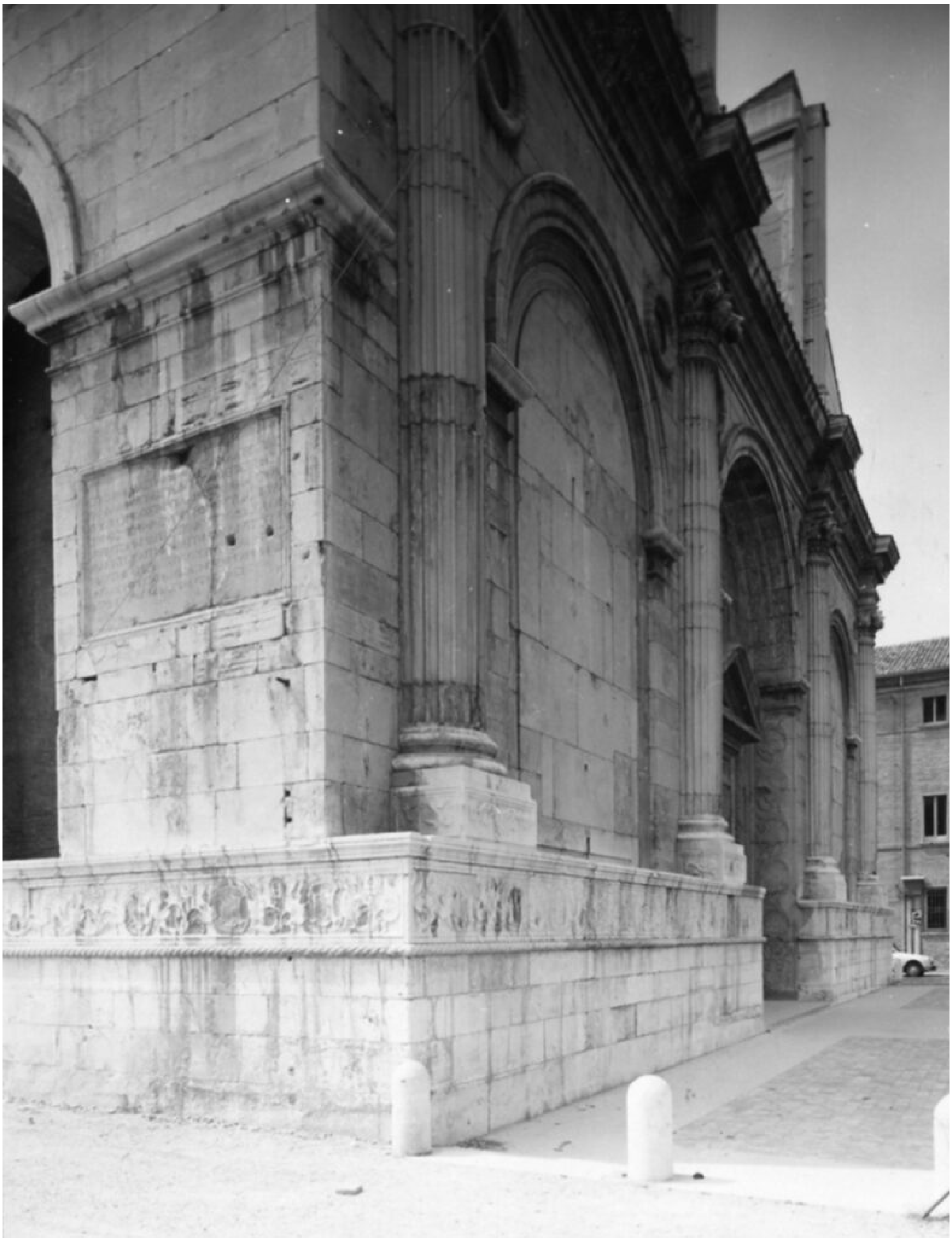


Figure 1 – Malatesta Temple, Alberti, c. 1450. Image: Paolo Monti, Servizio fotografico, Rimini, 1972.

Conversely, some centuries later authors like Ruskin, Viollet-le-Duc or Semper defended the relevance of matter in architecture, asserting that the choice of a material should depend on the laws dictated by its nature, such that "brick should look like brick; wood, wood; iron, iron, each according to its own mechanical laws."[6] Rondelet and Choissy also gave importance to the truth of the material, particularly throughout their exhaustive constructive drawings.

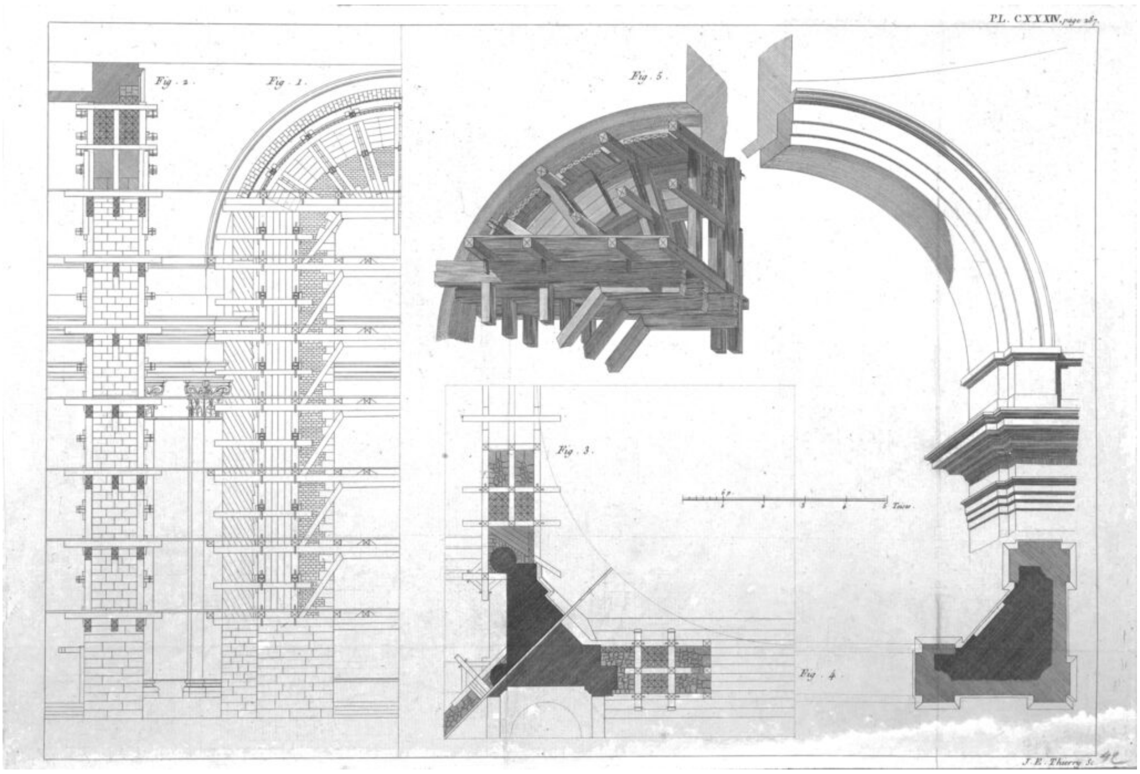


Figure 2 – Church Sainte Geneviève, Clovis, 502. Drawing by Jean-Baptiste Rondelet, 1810. Image: Thomas Thibaut, 2018.

However, this group of authors still remained idealistic: the use of materials was determined by the idea that the architectural object was intended to express. In that sense, and although its internal structure was recognised, matter was still subordinate to an external idea, that is, to an external form.

Some decades later, in his *Life of Forms in Art* (1881) Henri Focillon dignified matter through a strategy based on a different concept: vitalism. Although arguing that the development of art is inextricably linked to external socio-politic and economic characteristics, Focillon associated an autonomous formal mutation to it through underlining matter's inherent capacity of movement and metamorphosis. Already present in the Baroque and empowered by the Enlightenment's idea of "natura naturans", concepts like the "Bildungstrieb", the "Thatkraft" or the "Urpflanze" articulated a vitalist approach to matter closely related to German Expressionism. Ruskin and Semper's seminal materialism based on material's truth gave way to a radical pragmatism in which architects used hybridised materials in order to relate to natural metamorphosis. Many glass-based projects from the early 20th century replicate these morphogenetic processes, an attitude already present in the gothic. In resonance with Bergson's *élan vital,* a hypothetical force that explains the evolution and development of organisms, certain uses of concrete imitated the formal exuberance of some morphogenetic natural processes, as can be seen in the Goetheanum from Rudolph Steiner in 1928 or Einstein Tower from Erich Mendelsohn in 1921, but also with different materials in the Großes Schauspielhaus from Hans Poelzig in 1919.

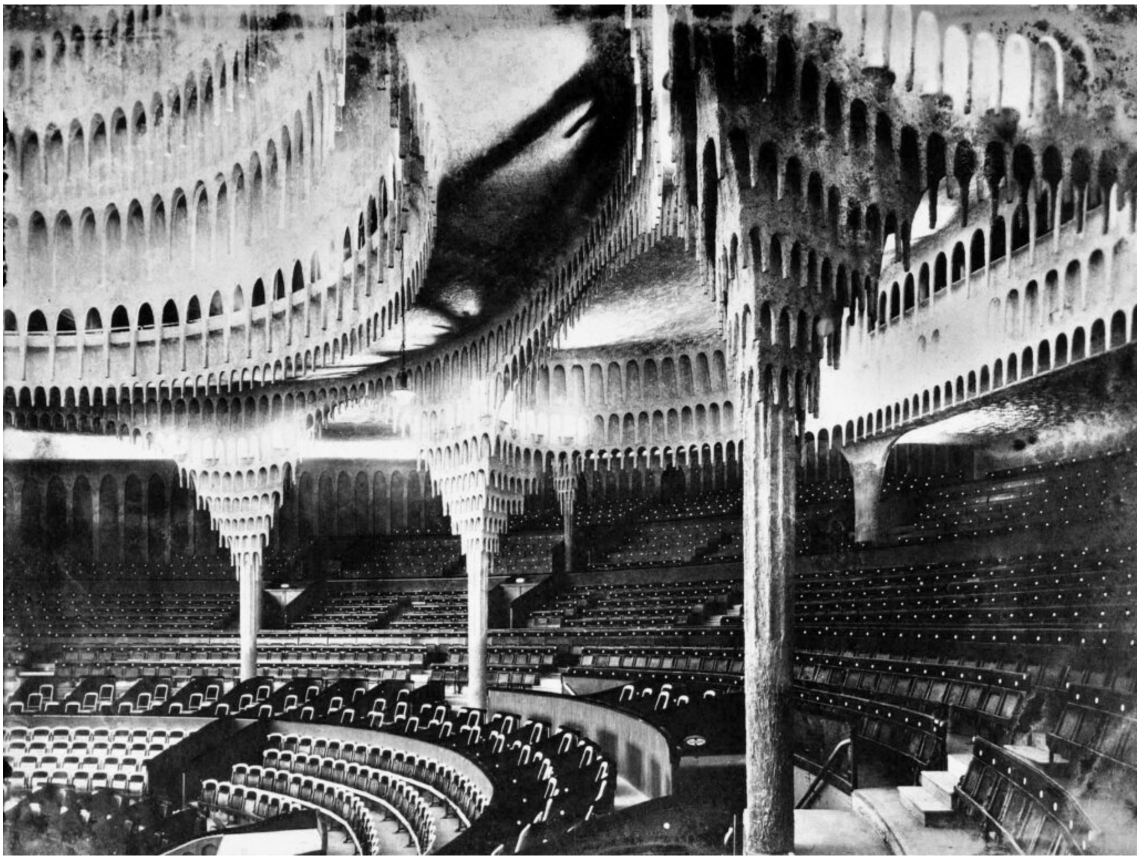


Figure 3 – Großes Schauspielhaus, Poelzig, 1919. Image: Image on paper 18,5 x 24,2, Architekturmuseum der Technischen Universität Berlin, 1919.

Moreover, the use of concrete established a continuity between form and structure characteristic of the organic beings that were so greatly admired at that time. As a consequence, a progressive material vitalism was thus constituted through an hylozoic approach based on Einstein's theories of matter and energy interconvertibility, which suggested a comprehension of matter as a set of energetical perturbations instead of mere inert mass. In this sense and according to Henry van de Velde, matter had not only a mechanical value, but an active dispositionality that was the consequence of its "formal vocation". However, vitalism had also its conservative reverse. Fueled by the phenomenological work of Rasmussen and Norberg-Schulz, architects such as Herzog & Meuron, Steven Holl or Peter Zumthor propose a haptic approach to architecture that relies on materials as symbolic shapers of architectural space. Under this scenario and in close relation to Merleau-Ponty's notion of "flesh", matter is still understood as a holistic repository of tactile and cultural memory.

In parallel to the general disdain that Modernism showed for materiality during the first half of the 20th century, according to Eduardo Prieto truthfulness and vitalism have gradually contributed to the reconsideration of matter as a substance with a certain agency.[7] This process was based not on the exaltation of the passivity, neutrality and homogeneity that originally characterised matter, but on the importation of attributes from the notion of form. Ruskin's truthfulness is based precisely on the understanding that matter has a specific inner character that makes it heterogeneous, while the vitalism of Steiner alludes to the metamorphic capacities of living beings.

However, both cases remain idealistic. Truthfulness asserts the need for an external form to choose the matter that best suits its purposes. Vitalism claims that matter should be seen as a material of organic expression that still needs an artist or architect to unveil its aesthetic potentialities of metamorphosis. In both cases, matter is still seen not just in opposition to an external form, but also under its control. In this sense, the vitalism defended by Bergson differs from the vitalism of Deleuze: for the former, matter is still a generic substance that needs an artist to particularise it, that is, needs an *élan vital* to form it. Conversely, for Deleuze, matter is an immanent reality: it provides form to itself and does not require any transcendental agent. This Deleuzian conception of matter has been emphasised today through New Materialism, whose statements in relation to the problem matter-form are based "on the idea that matter has morphogenetic capacities of its own and does not need to be commanded into generating form."[8] In this sense, matter is no longer seen in opposition to form, that is, "it is not a substrate or a medium for the flow of desire, but it is always already a desiring dynamism, a reiterative reconfiguring, energised and energising, enlivened and enlivening."[9]

This philosophical approach reverberates with our current technological condition. After the stages of truthfulness and vitalism, Sadin's antrobology culminates an architectural recovery of matter that paradoxically is based in the replacement of its signification by that of form. Faced with a dual ontology that is no longer alluding to Heideggerian human nudity but to a planet inhabited by algorithmic beings that live with and against us, Eric Sadin defines our technological scenario as Antrobological. This notion expresses the "increasingly dense intertwining between organic bodies and 'immaterial elfs' (digital codes)."[10] The propagation of artificial intelligence and the multi-scalar robotisation of the organic establishes, in addition to a change of medium, a change of condition: its algorithmic power does not merely offer itself as an automatic pilot for daily life, but it also triggers a radical transformation of our human nature, setting up a perennial and universal intertwining in between bodies and information. In this sense, the multidisciplinary generalisation of machine learning, progress in genetic engineering or the robotisation of the mundane no longer refer to a humanity that is merely improved or enriched, but to a humanity that is intertwined: it is unfolded through a physiological platform that is woven by algorithmic, organic, robotic and ecologic agents whose symbiosis is not metaphorical or narrative, but strictly performative. It is precisely under this scenario that "artificial extelligence" becomes "artificial intelligence": it executes an exercise of incorporation in which the intelligence, *eidos*, or what has traditionally been understood as form is no longer an external entity that articulates matter from outside, but is its immanent circumstance.

The historical and incremental process of matter legitimation, based initially on the truthfulness of Ruskin and the vitalism of Steiner, culminates today with the celebration of the notions of platform, information and performance that singularise Sadin's antrobology. Recent theorisations on concepts related to computation and design such as Keller Easterling's "medium"[11] or Benjamin Bratton's "stack"[12] are as well deeply underpinned by these three expressions. However, it is crucial to note that the term "form" is present in all of them, associating each expression to one of the three main form's attributes: structure (information), activity (performance) and heterogeneity (platform).

While matter "is that which resists taking any definite contour",[13] form refers to the active presence of a distinguished and qualified non-ultimate structure containing other forms at every level of scale and that can occasionally change and establish relationships. It is under this framework that the previous terms should be read in relation to experimental architecture. To provide a platform means to provide the conditions for an evolving intertwining in between forms that permits the promiscuous co-existence of difference, that is, of heterogeneity. Thus, a platform is not a field: in opposition to the latter, the former doesn't permit any sort of reductionism, that is, its elements are not mere emergences, as occurs with fields, but singularities with distinct origins. To provide information means to provide structure: it precludes disorder by establishing a spatio-temporal non-ultimate organisation. However, given that every entity already has a form and we cannot imagine a formless element, to inform means actually to transform. To provide performance, in contrast, means to present rather than represent: it produces an operative impact on the set of conditions in which it is placed, instead of merely representing an absent entity, as would be the case of a metaphor.

Under Sadin's antrobology, the disorder, passivity and homogeneity that traditionally identified matter are replaced by those characteristics that qualified form in the hylomorphic model: structure (information), activity (performance) and heterogeneity (platform). However, if the process of legitimation of matter is rooted in replacing its attributes by those of form, it is increasingly more unsustainable to keep referring to it as "matter", when actually, especially in Sadin's antrobology and from a hylomorphic point of view, matter is actually empty of matter and full of form.

Matter's Ultimate Condition and Part-Thinking

However, the rupture of the hylomorphic dichotomy caused by matter's absorption of form has implied the introduction of a pre-Socratic matter's condition: that of being ultimate. Matter is not understood anymore as one of the components of a dualistic model, but as a single holistic substance whose structure, activity and heterogeneity underlies the emergence of any specific entity. This model, technologically underpinned by Sadin's antrobology, has been articulated by contemporaneous experimental architecture according to the two types of materialism that differentiate pre-Socratic philosophy: as a continuous field (Anaximander's apeiron) or as discrete particles (Democritus's atoms). However, its common "ultimate" condition obstructs architectural part-thinking: if the notion of part demands an autonomy that cannot be exhausted neither in its outer participation in a bigger ensemble nor in its inner constitution through a smaller ensemble, matter's holism becomes problematic. Indeed, if any entity (part) can be deduced from a privilege underlying substrata (whole), its autonomy is called into question.

Anaximander's apeiron model is the most popular representative of pre-Socratic continuous approaches to matter. For the greek philosopher, apeiron refers to the notions of indefinite and unlimited, alluding explicitly to the origin (*arché*) of all forms of reality. Precisely because apeiron, as suggested by its etymology, is that which cannot be limited, it doesn't have in itself any specific form, that is, it is not definable. It is therefore a continuous material substrata, vague and boundaryless, capable of supporting the opposites from which all the world's differentiation emerges. Besides Bruno Latour's 'plasma', described by its author as that unknown and material hinterland which is not yet formatted, measured or subjectified, one of the most popular contemporaneous elaborations of this apeiron's holistic theory is Jane Bennett's "throbbling whole". For the American philosopher, objects would be "those swirls of matter, energy, and incipience that hold themselves together long enough to vie with the strivings of other objects, including the indeterminate momentum of the throbbing whole", something that according to Harman "we already encountered, in germ, in the pre-Socratic apeiron".[14] Beside pure formal continuities such as Alejandro Zaera's *Yokohama* (2000) or François Roche *Asphalt Spot* (2002), we can find a similar holistic vocation in projects such as Neri Oxman's BitMap Printing (2012), Mette Ramsgard Thomsen's *Slow Furl* (2008), and Poletto-Pasquero's Urban Algae Follies (2016). Its renovated notion of matter is usually referred to as behavioural matter, living matter, ecological matter, digital matter, expanded matter, data-driven matter or intelligent matter.

Paradoxically, what is relevant in all these expressions is not the term matter, but its qualifier, which systematically refers to spatio-temporal formal arrangements rather than hylomorphic matter attributes, emphasising the relevance of form as identifier over matter. Nery Oxman's "material ecology" is an emblematic example of this phenomena. Oxman defines this expression as "an emerging field in design denoting informed relations between products, buildings, systems and their environment".[15] The architect uses the term "informed" referring to information and therefore alluding to matter's inner structure. However, if "matter" is informed, it is no longer a homogeneous and amorphous substance, but it contains a digital or a physical structure that operates at every level of scale. Her project Bitmap Printing (2012) acts as a platform that intertwines between natural, human and algorithmic agents, whose activity has performative consequences rather than symbolic references. In this sense, given that the project is informed, acts as a platform and performs, it is hardly understandable why, under a hylomorphic scheme, we refer to them as specific configurations of matter rather than as a particular type of form.

However, these three projects, together with the work of authors such as Marcos Cruz, Phillip Beesley or Areti Markopoulou, introduce a pre-Socratic's matter attribute absent in the hylomorphic scheme: matter's condition of being ultimate. In particular, we can find this pre-Socratic's matter attribute in the continuous version developed by Anaximander through the notion of apeiron. As we can see in projects such as the Hylozoic Garden (2010) by Philip Beesley, full relationality and complete interconnectedness are the basis of a systemic approach to architecture in which the conceptual idea of field articulates Delanda's "continuous heterogeneity".

The project is based on the ancient belief that matter has life and should be understood, according to its author, as an active environment of processes rather than as an accumulation of objects. Unlike hylomorphic matter, the anti-maternalistic matter evoked by the Hylozoic Garden does not contain an Aristotelian pattern that provides structure to it, but is instead self-formed, that is, structured, active and heterogeneous. However, specific parts are always an emergence from an underlying holistic field, that is, a whole. Indeed, continuity is actually capable of producing objects, that is, continuity on one level creates episodic variation on the next that may be presented as discrete elements, but they are always dependent on this first gradual variation. Under this scheme, part-thinking is very limited because specificity is always a deduction from a privilege underlying substrata. Parts are then prevented from its autonomy, being instead exhausted in its participation as subsidiary members of a whole. As Daniel Koehler suggests, “departing from parts a preconceived whole or any kind of structure does not exist. Parts do not establish wholes, but measure quantities.”[16] And quantities, indeed, begin with individuals, that is, with discreteness.

However, the notion of “discreteness” needs differentiation: not all the interpretations of this term permit to understand its individuals as parts. In this sense, it is crucial to note that pre-Socratic philosophy articulates as well a type of materialism based on discreteness: beside the continuity emphasised by Anaximander’s apeiron, Democritus’s atomic model is the most popular representative of this discrete approach to matter. For the Greek philosopher, atoms are not just eternal and indivisible, but also homogeneous, that is, generic. Although atoms differ in form and size, its internal qualities are constant in all of them, producing difference only through its grouping modes. Atoms are then particles: generic individuals whose variable conglomerates produce the difference that we observe in the world. As Graham Harman affirms, this form of materialism is “based in ultimate material elements that are the root of everything and higher-level entities are merely secondary mystifications that partake of the real only insofar as they emerge from the ultimate material substrate.”[17]

The atomic model is thus a reductionist model: the different specificities that conform the world are mere composites of a privileged and ultimate physical element. In opposition to the continuous form of materialism, the discrete atomic type is easily misunderstood when it comes to considering its part-thinking capacities due to a frequent confusion: that between “part” and “particle”. This association is especially present nowadays in architectural experimental design, particularly under the notion of “digital” and its inherent discrete nature. Computation’s power of today has been aligned with this position through the recognition that “designers use the power of today’s computation to notate reality as it appears at any chosen scale, without converting it into simplified and scalable mathematical formulas or laws.”[18] It assumes “the inherent discreteness of nature”,[19] where the abstract continuity of the spline doesn’t exist. However, this process of architectural discretisation needs differentiation in order to be understood in relation to the notion of part, defined here as an interactive and autonomous element which is not just countable (mathematically discrete) but also distinct (ontologically discrete). Within the contemporaneous discrete project, three groups of architectural approaches to the notion of part, together with a speculative proposition, need to be distinguished according to its relation with matter's ultimate condition: topological parts, corpuscular parts, ecological parts and limital parts.

Topological Parts, Corpuscular Parts, Ecological Parts, Limital Parts

There is a first group of proposals in which parts are topological parts; in spite of the granular appearance of its architectural ensembles, its vocation is still derivative from the parametric project: the continuity of its splines has reduced its resolution through a process of "pixelisation", but it still operates under the material logic of an ultimate field. The notion of topology should be read here under the umbrella of the Aristotelian concept of *topos*. While Plato's term *chora* refers to a flat and neutral receptacle, the term topos refers to a variable and specific place. In contrast to the flat spaces of modernity, the three-dimensional variability of 1990s spaces produces topographic surfaces in which every point is singular. This results in "a constant modification of the space that leads to a changing reading of the place,"[20] implying the shift from Plato's chora to Aristotle's topos. Unlike the universal abstraction of the former, in the Physics, Aristotle "identifies the generic concept of space with another more empirical concept, that of 'place', always referred to with the term topos. In other words, Aristotle looks at space from the point of view of place. Every body occupies its specific place, and place is a fundamental and physical property of bodies."[21]

This is very clear in the following text by the Stagirite:

"Again, place (topos) belongs to the quantities which are continuous. For the parts of a body which join together at a common boundary occupy a certain place. Therefore, also the parts of place which are occupied by the several parts of the body join together at the same boundary at which the parts of the body do."[22]

Aristotle defines topos as a continuous and three-dimensional underlying substratum, but above all as an empirical and localised substratum.

The rhizomatic twists associated with these projects and underpinned by the intensive use of computational tools seem to oppose the homogeneity of its parts. According to Peter Eisenman, “while Alberti’s notational systems transcribed a single design by a single author, computation has the capacity to produce multiple iterations that the designer must choose from.”[23] Computers function as generators of variability, a fact that seems to promote Eisenman’s inconsistent multiples, calling into question Alberti’s homogeneous spatiality. However, in spite of being countable and distinct, the constitution of the parts associated with projects such as BIG’s Serpentine’s Pavilion (2016) and The Mountain (2008) or Eisenman’s Berlin Memorial (2005) is reducible to one single formula or equation, that is, a consistent and calculable single medium (parametricism). Its discrete look is provided by a set of elements which are countable, distinct and interactive, but that cannot be read as parts because its autonomy is restricted for a twofold reason: both its distinction and position depend on an ultimate system of relations which is external to the logics of its individuals, evoking therefore apeiron’s type of materialism. In this sense, parts here should be read as components: the location and form of them is subordinated to the topological bending of a general surface, precluding any type of part’s autonomy.

There is a second group of experimental projects in which parts are corpuscular parts. In these parts architectural ensembles are formalised through countable and qualitatively identical corpusculi, that is, individual entities which are not systematised by any external and preconceived structure. Its advocates follow a path similar – even if this is not their conscious intention – to that of Walter Gropius, Mies van der Rohe and Le Corbusier when they freed themselves from the straitjackets of the symmetry characteristic of 19th century’s Beaux-Arts, championed by architects such as Henri Labrouste or Felix Duban. However, corpuscular parts differ from modern parts in the fact that they are formally identical in between them despite performing different functions. Mario Carpo relates some of this work with Kengo Kuma’s Yure Pavilion (2015) and *GC* Prostho Museum Research Center (2010) under the expression “particlised.”[24] The term relates to the non-figural, aggregational or atomised way of producing architecture, in which Kuma states that “each element needs to be relieved from contact or structure beforehand, and placed under free conditions.”[25]

Experimental projects such as Bloom (2012) by Alisa Andrasek and José

Sánchez or Flow (2016) by Calvin Fung and Victor Huynh participate as well in this process of "particalisation" by relying on an ultimate, generic and privileged element: in opposition to modernist assemblies and in resonance with some of the early work of Miguel Fisac, "the buildings blocks are not predefined, geometric types – like columns or slabs – that only operate for a specific function,"[26] and unlike parametricism they do not derive from a predefined whole.

Instead, the particle's specific function is an emergent attribute of its interaction. In this sense, what gives specificity to these generic particles is not an a priori and fixed structure as modernism, but a posteriori and evolving relationality with the world. This is problematic with the requirement of autonomy demanded by parts for two reasons. On the one side, if part's specificity is exhausted with its outer relationality, its *nomos* is coming from outside and we are therefore in Kant's heteronomy rather than autonomy. On the other side, if parts are originally generic, they refer to an original standard type which is holistic precisely because it is shared by default by all its members. The fact that specificity is an emergent property in which parts are defined exclusively by their relationships with other parts has been interpreted as their emancipation with respect to the notion of whole. Timothy Morton describes this type of relational process as "simply the last philosophical reflex of modernity".[27]

Indeed, the instrumental reason characteristic of modernity is still behind this type of operation because emergent processes are teleological processes. "Emergence is always emergence for"[28] because there is always a holistic target that subjugates the parts to the benefit of the whole. As such, we are not dealing with a mereology of parts, but rather a mereology of particles: each element is not an incomplete piece that is unique in its identity and therefore irreducible (part), but rather a generic ultimate element that becomes specific at the price of being relationally dissolved into the whole of which it belongs (particle). Its being is defined precisely by the relationships it establishes with other elements, and those relationships are the way they are because they are beneficial to a whole.

Timothy Morton affirms that moving past modernity implies the need for a "philosophy of sparkling unicities; quantised units that are irreducible to their parts or to some larger whole; sharp, specific units that are not dependent on an observer to make them real."[29] Despite their local character, the relations that regulate individuals undervalue the parts on the one hand and overvalue the whole on the other. They undervalue the parts by fully determining their specific behaviour according to external factors, its original character being generic. They overestimate the whole by varying individual's specific behaviour according to the benefit of the whole. This position facilitates the emergence of a framework in which bits are associated literally with parts and the act of counting is frequently confused with an act of discretisation. It is then crucial to differentiate mathematical discreteness from ontological discreteness. While the first one alludes to countable elements (particles), the second one alludes to distinct elements (parts).

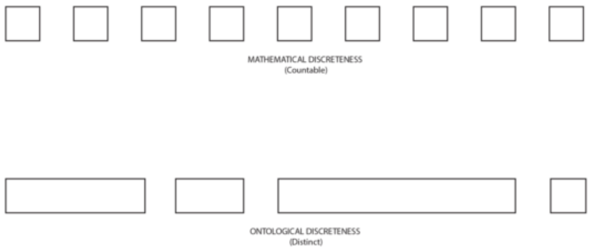


Figure 4 – Mathematical Discreteness, Ontological Discreteness, 2020. Image: Jordi Vivaldi, 2020.

The lack of distinction characteristic of generic particles prevents its approach through an exercise of architectural "part-thinking". Instead, we are confronted with the discrete type of materialism elaborated by pre-Socratic philosophy. Although its ultimate condition permits individual's participation, it ignores its autonomy's requirement for part-thinking under a masked heteronomy, which provides specificity to generic particles at the cost of its exhaustion under external relationality.

There is a third group of recent experimental architectural proposals in which parts are ecological parts; they operate as a set of distinct objects that intertwine with one another under the gravitational field of different systems. The notion of ecology should be interpreted here in keeping with the etymology of the Greek term *oikos*. Its meaning is that of "house" understood as the set of people and objects forming a domestic space and being regulated by the economy (the nomos of the oikos).

However, the term oikos has traditionally been associated with another very similar one: *oikia*. Both have been translated as "house", in the most general sense of the word. Nonetheless, Xenophon outlines a distinction[30] that, although not entirely accepted by all Greek authors, is very useful in approaching the question at hand. The Greek philosopher asserts that the expression *oikos* refers to a house in the strict sense of a place of residence, whereas the expression oikia denotes not only the house but also the property it contains and its inhabitants.

Based on this distinction, the word oikia would refer to a collection of elements of different natures and sizes whose coexistence and eventual interlacement would give rise to a specific spatial conception. It is formed not only by the house itself, but also by the property it contains (animals, instruments, jewellery, furniture, etc.) and its inhabitants. It would therefore be a large composite of objects whose eventual interlacements over time would form what Xenophon defines as domestic space. In that sense, these spaces not only contain and are contained by other spaces simultaneously, they also never appear as completely closed elements, despite remaining identifiable and extractable. Oikia is then not produced from a passive Platonic receptacle (chora) or an active Aristotelian substrate (topos); it is constructed instead from the multi-scalar co-existence of various groups and subgroups of systems. The ecological parts characteristic of this branch of experimental architectural projects represent, in different ways, a departure from the materialism analysed in previous cases. They find an example *avant la lettre* in the work of Jean Renaudie, particularly in his two housing complexes in Ivry sur Seine (1975) and Givors (1974).

Although not all parts fully coincide with the definition provided here, the discreteness of the projects operates with autonomous discrete entities that cannot be interpreted under a materialistic framework; there is no ultimate element acting as an underlying substrata (continuous or discrete) to which entities can be reduced. However, as we have seen, the notion of ecology implies the presence of oikia, that is, a house, a common denominator whose presence can be traced in these projects by a formal homogeneity that traverses the whole composition.

We can find a wide range of experimental architectural formal strategies working in this direction. Daniel Kohler's Hyper-Nollie (2019) develops a complicit discreteness with more than 40 different parts that are always cooperative and incomplete, never single entities, never fully defined, never identical. However, the continuous connection of its spaces and the fact that each one of them is accessible from each part seem to formally evoke the logics of a relational field, particularly through the homogeneous granularity revealed by a general overview. Nevertheless, the project's tension between the distinct discreteness of its close view and the texturised continuity of its far-view precludes any attempt to simply reduce its parts to an underlying material substrata: each part positions its own context's interpretation through a complex balance in between identity (inherent distinction) and relationality (local complicities).

Although its assumption of the voxel as a standard unit and its complicity with Christopher Alexander's notion of structure, Jose Sánchez's Block'hood (2016) tends as well to avoid the possibility of any full material reductionism to any ultimate being. In spite of its underlying 3D grid, the project provides each voxel with a specific performative behaviour whose specificity is not merely underpinned by relationality, but is partly inherent to its constitution. In this sense, each unit approaches our definition of part because despite its underlying common framework, voxel's singularity cannot be merely reduced to it or to its relations. Rasa Navasaityte's Urban Interiorities (2015) approaches the notion of part through a recursive structure of groups inside groups: there is not any ultimate element from which the rest of compositions can be derived, but a recursive process.This partly acts as a holistic system of form production, at the same time permitting the presence of distinction beyond countability.

These projects represent the different nuances of a part: they operate through the tension established in between part's autonomy and part's participation, e.g. the part's capacity to be inherently distinct and at the same time the part's capacity to retain something in common with other parts in order to permit local and ephemeral complicities. This type of mereology resonates with what Levi Bryant has defined as a "strange mereology": "one object is simultaneously part of another object and an independent object in its own right."[31] Indeed, on the one side, the parts that we have seen in this last group of projects are autonomous beings in the world that cannot be reduced to other parts. But at the same time, parts are composed by other parts, compose other parts, and relate with other parts. In synthesis, part-thinking demands parts execute what seems to be a paradox: its constitution as a countable and distinct entity that is both independent and relational.

We could synthesise the different approaches towards the definition of part presented here as follows: the first group of projects, constituted by what we have defined as topological parts, leaves aside part's autonomy in favour of an underlying field of relations. The second group, whose parts are defined as corpuscular parts, emphasises part's countability (mathematical discreteness) instead of part's inherent distinction (ontological discreteness). The third group, composed by ecological parts, still retains a vague remainder of a general background (oikia) that vectorises part's distribution. In all of them, matter's ultimate condition is still present, although in a blurry and definitely weakened version, particularly in the last one. However, we could briefly speculate with a fourth group of architectural parts, associated with the notion of limit, that would emerge from the radical limitation of matter's ultimate condition.

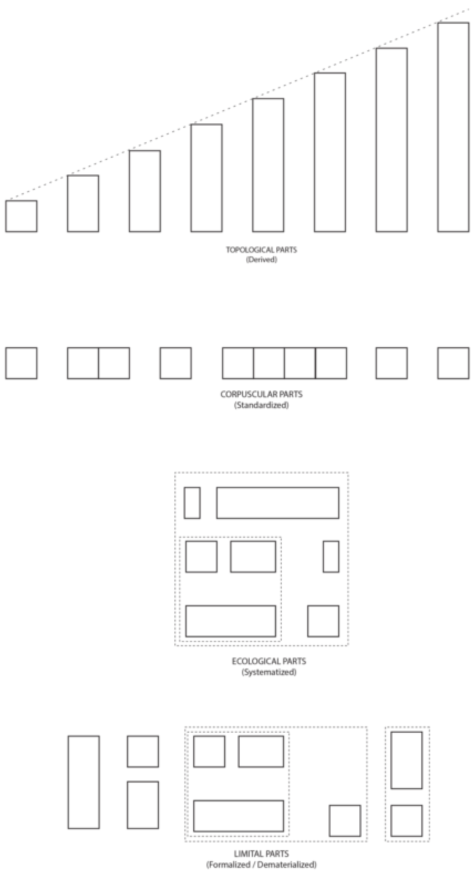


Figure 5 – Topological, Corpsular, Ecological and Limital Parts, 2020. Image: Jordi Vivaldi, 2020.

The notion of limit is at the core of architecture. If we understand the architectural practice as the production of interiorities, that is, as the production of spaces within spaces, the idea of a border distinguishing them is decisive. In this sense, the etymology of the term "temple" is particularly revealing: its root "-tem", present also in the terms *témenos*, *templum*, and "time", indicates the idea of a cutout, a demarcation, a frontier, a limit instrumentalised in order to separate the sacred realm of the gods from the profane territory of humans. In ancient Rome, the construction of a temple began with the *cumtemplatio*, the contemplative observation of a demarcated zone of the sky by the augurs. Through the attentive observation of birds, the sun and the clouds' trajectories within the selected celestial area, the augurs interpreted the auspices of the city that was about to be founded. Once the observation was completed, the demarcated zone of the sky was projected onto the ground in order to trace the contours of the future temple, the germinal cell of the coming city. Cumtemplatio was thus cum-tem-platio: the tracing of the limits through which the cosmos took on meaning and signification by being projected onto the earth and establishing the ambit in which the humans could purposively inhabit the world. Thus, the temple instrumentalised the limit not just as a border between what is sacred and what is profane, that is, between inside and outside, but also as a space in itself, as a frontier territory mediating between the celestial realm of the gods and the terrestrial realm of humanity.

The spatialised register of the limit evoked by the temple and aligned with notions such as the Christian *limbo* or the Roman *limes*, lays the foundation for the type of immaterialist parts hypothesised here with the expression *limital* parts. They expand the decreasingly shy immaterialism present in topological parts, corpuscular parts and ecological parts by limiting the reduction to any sort of matter's ultimate condition. In order to do so, limital parts are liminal, limited, and limitrophe, three decisive attributes aligned with supercomputation's capacity to avoid parametric reductionism.

First, limital parts are liminal, that is, they are the *locus* of junction and disjunction. The notion of liminality should be read under its instrumentalisation by Arnold van Gennep and Victor Turner: the limit is not the Euclidean divider line that is at the core of the Modern Movement's programmatic zonification, but, the limit is, in its anthropological register, the frontier territory that in a rite of passage mediates between the old and new identity of its participants. Parts's liminality constitutes a daimonic space whose nature is that of "differential sameness and autoreferential difference,"[32] if the limit is in itself and by itself internal differentiation, if in its re-flection the limit separates and divides, then limital parts should necessarily join and disjoin, or, more accurately, limital parts should join what they disjoin. The liminality of limital parts does not mean that its composition is simply the random juxtaposition of a litany of solipsistic monades: in their symbiotic intertwinings, the different liminal parts establish clusters and sub-clusters of performative transfers that are constantly sewing and resewing the limit's limits: their operativity is not always structured by harmonic consensus, but they engage in constant resistance and deviation. They produce spontaneous symbiotic interlacements that overlap without any preconceived agreement and certainly not without *décalages*, displacements and misfits.

Second, limital parts are limited, that is, they are distinct and determined. The notion of limitation should be read under its Hegelian instrumentalisation: "The limit is the essentiality of something, it is its determination."[33] Thus, to limit means to define; the latin term *definire* signifies to trace the borders of something in order to separate it from its neighbours. *Definire* is the establishment of *finis*, ends. However, the term finis should not be read here only under the light of its topological or chronological sense, but it should also be approached in its ontological register: to define means to specify the qualities of a part that make a part this part and not that part, avoiding its reduction to any ultimate material substrata. It traces an ontological contour in order to limit the part's infinite possible variability. A limited part refers thus to a distinct part; it is determined, but not predetermined, that is, it is not determined avant la lettre. It contrasts with what is open, flexible and generic; in a context where the power of today's supercomputation makes it possible to notate the inherent discreteness of reality, it is no more necessary to design with simplified spatial formulas (fields), or repetitive spatial blocks (particles). Today's computational power applied to architectural design allows an emancipation from reductive laws, whose standardisation is at the core of the material remanences of topological parts, corpuscular parts and ecological parts. Thus, rather than formulative and open parts, the unprecedented power unfolded by supercomputation lets us operate with massive sets and sub-sets of distinct parts. The limited condition of limital parts does not align with the notion of the generic, nor with derivative concepts such as flexibility, adaptability or resilience, so common in the three previous groups of architectural parts. Thus, rather than flexible, limital parts are plastic (*plastiquer*, *plastiquage*, associated in French to the notion of explosion): they vary, but at the price of gaining a new specificity and cancelling the previous one.

Third, limital parts are limitrophe, that is, they are foliated. The notion of limitrophy should be read in light of its instrumentalisation by Jacques Derrida. Rather than effacing or ignoring the limit, Derrida attempts, through his use of the term "limitrophy", "to multiply its figures, to complicate, thicken, delinearize, fold, and divide the line precisely by making it increase and multiply."[34] Limital parts are thus thickened, which is the literal sense of the Greek term *trepho*, that is, to nurture. Under this umbrella, a limitrophe part is not a solipsistic monade or a fragment referring to an absent whole. Limital parts produce inconsistent multiplicities by acquiring a foliated consistency and becoming an edgy, plural and repeatedly folded frontier. Limital parts shouldn't orchestrate thus an abyssal and discontinuous limit: the latter does not form the single and indivisible line characteristic of modernity, rather, it produces "more than one internally divided line."[35] Thus, limital parts grow and multiply into a plethora of edges. Precisely because of their liminal, limited and limitrophe condition, limital parts are immaterialist: they are not reducible to one, as is the case, with decreasing intensity, of topological parts, corpuscular parts or ecological parts.

Ending Considerations

Avoiding matter's ultimate condition requires understanding form as a spatio-temporal structure that operates at every level of scale. It demands the assumption that there is always a form beyond any given form, avoiding any continuous (field) or discrete (particle) ultimate background in which parts could be reduced. In this sense and as Graham Harman affirms, "although what is admirable in materialism is its sense that any visible situation contains a deeper surplus able to subvert or surprise it,"[36] the kind of formalism approached here does not deny this surplus, it merely states that this surplus is also formed.

The impossibility of conjugating matter's ultimate condition with a radical part-thinking would suggest a *pan-formalism* based on a *Matryoshka* logic, a multiscalar recursivity that doesn't rely on an ultimate and maternal underlying *substrata*. Under this framework and building on the German and Russian formalist traditions later developed by figures such as Colin Rowe, Alan Colquhoun, Alexander Tzonis or Liane Lefaivre, the formalism that could emerge from these statements shouldn't be understood in the sense that there is no excess beneath the architectural forms that are given, rather, in the sense that "the excess is itself always formed."[37]

The constant and multiscalar presence of form and the avoidance of any ultimate substrata are posited as the two conditions that a radical part-thinking would require; they represent the only way in which the notion of part can be understood in its full radicality, that is, as an interactive and autonomous element which is not just countable (mathematically discrete) but also distinct (ontologically discrete). As we have seen, this approach is incompatible with matter's understanding: despite matter's revival has paradoxically imported all the attributes associated with the hylomorphic understanding of form, the re-introduction of pre-Socratic's ultimate condition represents the clandestine re-introduction of the notion of whole and therefore an unsurpassable obstacle for part-thinking.

Article 6 : Affordances of Decentralised Technologies for Commons-based Governance of Shared Technical Infrastructure

Architecture Theory

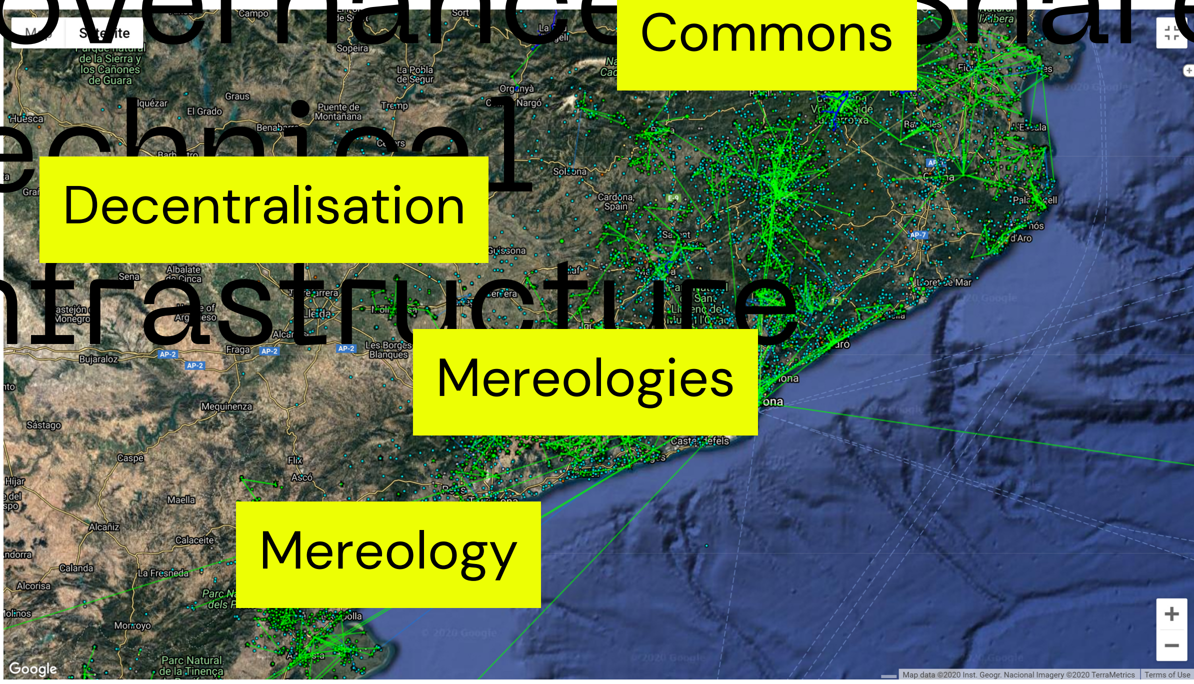
Blockchain

Commons

Decentralisation

Mereologies

Mereology



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In this article I will illustrate affordances of decentralised technologies in the context of commons governance. My aim is to summarise the conversation around the lecture “When Ostrom Meets Blockchain: Exploring the Potentials of Blockchain for Commons Governance” I gave in the Mereologies Open Seminar organised by The Bartlett School of Architecture at University College London on 25th April 2019. I will also extend the conversation by providing a concrete example of such affordances in the context of a community network.

What is Blockchain? Three Key Concepts around Decentralised Technologies

In 2008, an anonymous paper presented Bitcoin: the first cryptocurrency based purely on a peer-to-peer system.[1] For the first time, no third parties were necessary to solve problems such as double-spending, thanks to cryptography. The solution was achieved through the introduction of a data structure known as a blockchain. In simple terms, a blockchain can be understood as a distributed ledger. Distributed refers to a technical property of a system in which certain components are located on different computers connected through a network. The blockchain, in this sense, can be thought of as a “decentralised book” in which agreed transactions can be stored in a set of distributed computers. Data, such as the history of monetary exchanges generated by using cryptocurrencies, can be stored in a blockchain. The key aspect resides in the fact that there is no need to trust a third party, such as a bank server, to store that information.

Nakamoto’s article opened what is considered to be the first generation of blockchain technologies.[2] This generation, up to approximately 2013, includes Bitcoin and a number of crypto-currencies that appeared after it. The second generation, approximately from 2014 onwards, is the extension of these blockchains with capabilities beyond currencies in the form of automatic agreements or smart contracts.[3] Smart contracts can be understood as distributed applications which encode clauses that are automatically enforced and executed without the need for a central authority. They can be employed, for example, to enable the execution of code to provide certifications, such as obtaining a diploma or a registry of lands, according to previously mutually agreed rules. Again, the novel aspect here is the fact that the execution of such rules, in the form of computer instructions, is distributed across a large number of computers without the need of a central point of control.

Complex sets of smart contracts can be developed to make it possible for multiple parties to interact with each other. This fostered the emergence of the last of the concepts I will introduce around decentralised technologies: Decentralised Autonomous Organisations (DAO). A DAO is a self-governed organisation in which interactions between the members of the organisation are mediated by the rules embedded in the DAO code. These rules are sets of smart contracts that encode such interactions. The rules embedded in the code are automatically enforced by the underlying technology, the blockchain, in a decentralised manner. DAOs could, for example, hire people to carry out certain tasks or compensate them for undertaking certain action. Overall, this can be understood as analogous to a legal organisation, with legal documents – bylaws – which define the rules of interaction among members. The development of DAOs has been, unsurprisingly, significantly popular around financial services.[4] However, DAOs could be used to provide a wide variety of services or management of resources in a more diverse range of areas. A more artistic example of a DAO is the Plantoid project,[5] a sculpture of a plant, which can hire artists to physically modify the sculpture itself according to the rules collectively agreed in the smart contracts encoded in it.

All of these potentials of decentralised technologies represent an emerging research field. Together with other colleagues of the EU project P2PModels,[6] we are exploring some of these potentials and limitations in the context of the collaborative economy and, more precisely, on some of the models emerging around Commons-Based Peer Production.

Collaborative Economy and Commons-Based Peer Production

The collaborative economy is a growing socio-economic phenomenon in which individuals produce, exchange and consume services and goods, coordinating through online software platforms. It is an umbrella concept that encompasses different initiatives and significantly different forms are emerging; there are models where large corporations control the platform, thus ensuring its technologies and the knowledge held therein are proprietary and closed. Uber, a riding service, and AirBnB, a short-term lettings service, are perhaps the most well-known examples of such initiatives. They differ from models that revolve around Commons-Based Peer Production (CBPP), where individuals produce public goods by dispensing with hierarchical corporate structures and cooperating with their peers.[7] In these models, participants of the community govern the assets, freely sharing and developing technologies.[8] Some of the most well-known examples of the initiatives around such commons-based models are Wikipedia and GNU/Linux, a Free/Libre Open Source Software (FLOSS) operating system. Commons-based models of the collaborative economy are, however, extending to areas as broad as open science, urban commons, community networks, peer funding and open design.[9]

Three main characteristics are salient in the literature on CBPP.[10] Firstly, CBPP is marked by decentralisation, since authority resides in individual agents rather than a central organiser. Secondly, it is commons-based since CBPP communities make frequent use of common resources. These resources can be material, such as in the case of 3D printers shared in small-scale workshops known as Fab Labs; or immaterial, such as the wiki pages of Wikipedia or the source code in a FLOSS project. Thirdly, non-monetary motivations are prevalent in the community. These motivations are, however, commonly intertwined with extrinsic motivations resulting in a wide spectrum of forms of value operating in CBPP communities,[11] beyond monetary value.[12]

Guifi.net: An Example of a CBPP Community in Action

In order to extend the discussion of the affordances of decentralised technologies in CBPP, I will employ Guifi.net as an illustrative example. Guifi.net[13] is a community network: a participatory project whose goal is to create a free, open and neutral telecommunications network to provide access to the Internet. If you are reading this article online, you might be accessing it through a commercial Internet Service Provider. These are the companies which control the technical infrastructure you are using to connect to the Internet. They manage this infrastructure as a private good. The Guifi.net project, instead, manages this infrastructure as a commons. In other words, Guifi.net is organised around a CBPP model,[14] in which the network infrastructure is governed as a common good. Over the past 16 years, participants of Guifi.net have developed communitarian rules, legal licenses, technological tools and protocols which are constantly negotiated and implemented by the participants.

I have chosen to discuss the potentialities of blockchain drawing on Guifi.net, a community network, for two main reasons. Firstly, the most relevant type of commons governed in this case is shared infrastructure, such as fibre optic and routers. The governance of rival material goods, in contrast to the commons governance of non-rival goods such as source code or wiki pages, better matches the scope of the conversations which emerged during the symposium around architecture of the commons and the role played by participatory platforms.[15] Secondly, Guifi.net provides a large and complex case of governance of shared infrastructure. The growth experienced by Guifi.net's infrastructure and community since the first pair of nodes were connected in a rural region of Catalonia in 2004 is significant. In their study of the evolution of governance in Guifi.net, Baig et al. reported a network infrastructure consisting of more than 28,500 operational nodes which cover a total length of around 50,000 km of links that are connected to the global Internet. This study refers to the period 2005–2015.[16] The latest statistics reported by Guifi.net state that there are more than 35,000 operational nodes and 63,000 km of links.[17] Beyond the infrastructure, the degree of participation in the community is also significant: more than 13,000 registered participants up to 2015, according to the aforementioned study, and more than 50,000 users of this community network connect on a day to day basis, as reported by the community at present.[18] Thus, Guifi.net provides a suitable scenario for the analysis of the affordances of decentralised technologies for commons governance.

Ostrom's Principles and Affordances of Decentralised Technologies for Commons Governance

How do communities of peers manage to successfully govern common resources? The study of the organisational aspects of how common goods might be governed was traditionally focussed on the study of natural resources. This commons dilemma was explored by Hardin in his influential article "The Tragedy of the Commons", whose ideas became the dominant view. In this article, Hardin states how resources shared by individuals acting as homo economicus (out of self-interest in order to maximise their own benefit) results in the depletion of the commons. The individuals' interests enter into conflict with the group's, and because they act independently according to their short-term interests, the result of the collective action depletes the commons.[19] As a consequence, in order to avoid this logic – "If I do not use it, someone else will", which is not sustainable – it was necessary to manage these commons through either private ownership or centralised public administration.

Later on, Nobel laureate researcher Elinor Ostrom questioned and revisited "The Tragedy of the Commons". In her work, she showed how under certain conditions commons can indeed be managed in a sustainable way by local communities of peers. Her approach took into account that individual agents do not operate in isolation, nor are they driven solely by self interest. Instead, she argued that communities communicate to build processes and rules, with different degrees of explicitation, that ensure their sustainability.[20] This hypothesis was supported by a meta-analysis of a wide range of case studies,[21] and has been confirmed in subsequent research.[22] As part of this work, she identified a set of principles for the successful management of these commons,[23] which has also been subsequently applied to the study of collaborative communities whose work is mediated by digital platforms, such as Wikipedia and FLOSS communities:[24]

1. Clearly defined community boundaries: in order to define who has rights and privileges within the community.

2. Congruence between rules and local conditions: the rules that govern behaviour or commons use in a community should be flexible and based on local conditions that may change over time. These rules should be intimately associated with the commons, rather than relying on a "one-size-fits-all" regulation.

3. Collective choice arrangements: in order to best accomplish congruence (with principle number 2), people who are affected by these rules should be able to participate in their modification, and the costs of alteration should be kept low.

4. Monitoring: some individuals within the community act as monitors of behaviour in accordance with the rules derived from collective choice

arrangements, and they should be accountable to the rest of the community.

5. Graduated sanctions: community members actively monitor and sanction one another when behaviour is found to conflict with community rules. Sanctions against members who violate the rules are aligned with the perceived severity of the infraction.

6. Conflict resolution mechanisms: members of the community should have access to low-cost spaces to resolve conflicts.

7. Local enforcement of local rules: local jurisdiction to create and enforce rules should be recognised by higher authorities.

8. Multiple layers of nested enterprises: by forming multiple nested layers of organisation, communities can address issues that affect resource management differently at both broader and local levels.

What kind of affordances do decentralised technologies offer in the context of commons governance and, more concretely, with regards to Ostrom's principles? Together with other colleagues,[25] we have identified six potential affordances to be further explored.

Firstly, tokenisation. This refers to the process of transforming the rights to perform an action on an asset into a transferable data element (named *token*) on the blockchain. For example, tokens can be employed to provide authorisation to access a certain shared resource. Tokens may also be used to represent equity, decision-making power, property ownership or labour certificates.[26]

Secondly, self-enforcement and formalisation of rules. These affordances refer to the process of embedding organisational rules in the form of smart contracts. As a result, there is an affordance for the self-enforcement of communitarian rules, such as those which regulate monitoring and graduated sanctions, as reflected in Ostrom's principles 4 and 5. This encoding of rules also implies a formalisation, since blockchain technologies require these rules to be defined in ways that are unambiguously understood by machines. In other words, the inherent process of explicitation of rules related to the use of distributed technologies also provides opportunities to make these rules more available and visible for discussion, as noted in Ostrom's principle 2.

Thirdly, autonomous automatisation: the process of defining complex sets of smart contracts which may be set up in such a way as to make it possible for multiple parties to interact with each other without human interaction. This is analogous to software communicating with other software today, but in a decentralised manner. DAOs are an example of autonomous automatisation as they could be self-sufficient to a certain extent. For instance, they could charge users for their services.[27]

Fourthly, decentralised technologies offer an affordance for the decentralisation of power over the infrastructure. In other words, they can facilitate processes of communalising the ownership and control of the technological artefacts employed by the community. They do this through the decentralisation of the infrastructure they rely on, such as collaboration platforms employed for coordination.

Fifthly, transparency: for the opening of organisational processes and the associated data, by relying on the persistency and immutability properties of blockchain technologies.

Finally, decentralised technologies can facilitate processes of codification of a certain degree of trust into systems which facilitate agreements between agents without requiring a third party. Figure 1 below provides a summary of the relationships between Elinor Ostrom's principles and the aforementioned affordances.[28]

	(I) Tokenisation	(II) Self-enforcement and formalisation	(III) Autonomous automatisation	(IV) Decentralisation of power over infrastructure	(V) Transparentisation	(VI) Codification of trust
(1) Clearly defined community boundaries	✔					
(2) Congruence between rules and local conditions	✔	✔		✔		
(3) Collective choice arrangements	✔			✔		
(4) Monitoring		✔	✔	✔	✔	
(5) Graduated sanctions		✔	✔			
(6) Conflict resolution mechanisms			✔		✔	
(7) Local enforcement of local rules		✔		✔		✔
(8) Multiple layers of nested enterprises			✔			✔

Figure 1 – Summary of the relationships between the identified affordances of blockchain technologies for governance and Ostrom's principles (Ostrom, 1990). Image credit:, identified by Rozas et al., 2018.

These congruences allow us to describe the impact that blockchain technologies could have on governance processes in these communities. These decentralised technologies could facilitate coordination, help to scale up commons governance or even be useful to share agreements and different forms of value amongst various communities in interoperable ways, as shown by Pazaitis et al..[29] An example of how such affordances might be explored in the context of CBPP can be found in community networks such as Guifi.net.

A DAO for Commons Governance of Shared Technical Infrastructure

Would it be possible to build a DAO that might help to coordinate collaboration and scale up cooperative practices, in line with Ostrom's principles, in a community network such as Guifi.net? First of all, we need to identify the relationship between Ostrom's principles and Guifi.net. We can find, indeed, a wide exploration of the relationship between Ostrom's principles and the evolution in the self-organisational processes of Guifi.net in the work of Baig et al..[30] They document in detail how Guifi.net governs the infrastructure as a commons drawing on these principles, and provide a detailed analysis of the different components of the commons governance of the shared infrastructure in Guifi.net.

Secondly, we need to define an initial point of analysis, and tentative interventions, in the form of one of the components of this form of commons governance. From all of these components, I will place the focus of analysis on the economic compensation system. The reason for selecting this system is twofold. On the one hand, it reflects the complexity behind commons governance and, thus, allows us to illustrate the aforementioned principles in greater depth. Secondly, it is an illustrative example of the potential of blockchain, as we shall see, to automatise and scale up various cooperative processes.

The economic compensation system of Guifi.net was designed as a mechanism to compensate imbalances in the uses of the shared infrastructure. Professional operators, for example, are requested to declare the expenditures and investments in the network. In alignment with Ostrom's principle number 4, the use, expenditure and investments of operators are monitored, in this case by the most formal institution which has emerged in Guifi.net: the Guifi.net Foundation. The Foundation is a legal organisation with the goal to protect the shared infrastructure and monitor compliance with the rules agreed by the members of the community. The community boundaries, as in Ostrom's principle number 1, are clearly defined and include several stakeholders.[31] Different degrees of commitment with the commons were defined as collective choice arrangements (principle number 3). These rules are, however, open to discussion through periodic meetings organised regionally, and adapted to the local conditions, in congruence with principle number 2. If any participant, such as an operator, misuses the resources or does not fulfill the principles, the individual is subject to graduated sanctions,[32] in alignment with principle number 5. As part of the compensation system, compensation meetups are organised locally to cope with conflict resolution, in congruence with principle 6. Principles 6 and 7 are also clearly reflected in the evolution of the governance of Guifi.net, although they are more closely associated with scalability.[33]

The compensation DAO could be formed by a set of local DAOs, whose rules are defined and modifiable exclusively by participants holding a token which demonstrates they belong to this node. These local DAOs could be deployed from templates, and could be modified at any point as a result of a discussion at the aforementioned periodic meetings held by local nodes and in congruence with the local conditions. Among the rules of the smart contracts composing these DAOs, participants may decide to define the different factors that are considered when discussing the local compensation system arrangements, as well as graduated sanctions in case of misuse of the common goods. These rules might be copied and adapted by some of the nodes facilitating the extension of the collaborative practices.

Some of the settings of these local DAOs could be dependent on a federal compensation DAO that defines general aspects. A mapping of the current logic could consist of reaching a certain degree of consensus between the participants in all of the nodes, but having this process approved by the members of the Foundation, who would hold a specific token. Examples of general aspects regulated by the federal DAO are the levels of commitment towards the commons of each operator, which is currently evaluated and monitored manually by the Foundation. General aspects such as this could be automatised in several ways therefore moving from manual assignations by the Foundation, as is currently the case, to automatically assigned tokens depending on the communitarian activities tracked in the platform. This is an example of a possible intervention to automatise certain collaborative practices assuming the current structure. Figure 1 below provides an overview of a preliminary design of a DAO for a compensation system mapping the current logics.

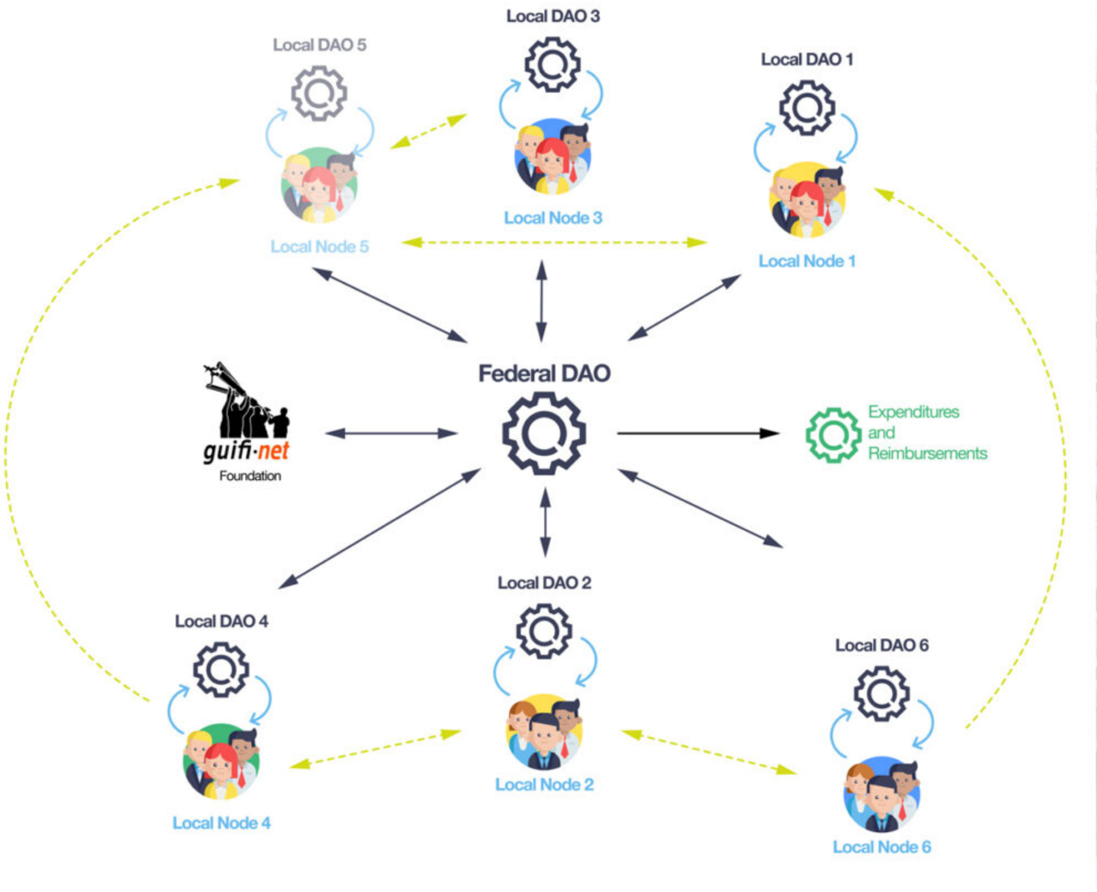


Figure 2 – A proposal of a simple compensation DAO. The green arrows represent the extension of practices between local DAOs, including new nodes such as number 5. Black arrows represent the interactions between the local DAOs and the federal DAO, in congruence with Ostrom's principle 8. Image credit: Rozas, et al, 2018.

More disruptive tentative interventions could consist of the implementation of more horizontal governance logics which allow modifications of the rules at a federal level or to transform the rules that regulate the monitoring. These interventions, however, should be carefully co-designed together with those who participate in the day-to-day of these collectives. Our approach states that the development of decentralised tools which support commons governance should be undertaken as a gradual process to construct situated technology, with an awareness of the cultural context and aiming to incorporate particular social practices into the design of these decentralised tools.

This basic example of a DAO illustrates, on the one hand, the relationship with Ostrom's principles: monitoring mechanisms, local collective choice arrangements, graduated sanctions and clear boundaries. These principles are sustained by the aforementioned affordances of blockchain for commons governance. For example, tokenisation with regards to providing permission as to who has the ability to participate in the choices locally and at a federal level and how, as well as the certification of the level of commitment to the commons; monitoring of the expenditures and reimbursements through the transparency provided by the blockchain; self-enforcement, formalisation and automatisation of the communitarian rules in the form of smart contracts. Another, more general, example of this is the increment in the degree of decentralisation of power over the platform because of the inherent decentralised properties of the technology itself. In this way, this could result in a partial shift of power over the platform from the Foundation towards the different nodes formed by the participants. Furthermore, as discussed, the fact that such rules are encoded in the form of configurations of smart contracts could facilitate the extension of practices and the development of new nodes; or even the deployment of alternative networks capable of operating as the former network, and reusing and adapting the encoded rules of the community while still using the shared infrastructure. Overall, further research of the role of decentralised technologies in commons governance offers, in this respect, a promising field of experimentation and exploration of the potential scalability of cooperative dynamics.

Discussion and Concluding Remarks

In this article I provided an overview and discussed an example of the affordances of blockchain technologies for commons governance. Concretely, I described such potentialities drawing on the example of a DAO to automatise some of the collaborative processes surrounding the compensation system of a community network: Guifi.net. Throughout this example, I aimed to illustrate, in more detail, the affordances of blockchain for commons governance which I presented during the symposium. The aim of this example is to illustrate how blockchain may facilitate the extension and scaling up of the cooperation practices of commons governance. Further explorations, more closely related to the architecture field, could explore the discussed affordances for commons governance with discrete design approaches that provide participatory frameworks for collective production.[34] In this respect, decentralised technologies offer opportunities of exploration to tackle challenges such as those identified by Sánchez[35] to define ways to allocate ownership, authorship and distribution of value without falling into extractivist practices.

A better understanding of the capabilities of blockchain technologies for commons governance will require, however, further empirical research. Examples of research questions which need to be addressed are those with regards to the boundaries of the discussed affordances. For example, with regards to tokenisation and formalisation of rules: which aspects should remain in/off the blockchain, or furthermore completely in/out of code?

Overall, CBPP communities provide radically differing values and practices when compared with those in markets. In this respect, the study of the potentialities and limitations of blockchain technologies in the context of the governance of CBPP communities offers an inspiring opportunity to take further steps on a research journey that has only just begun.

Article 7 : Mereologies Open Seminar: Round Table Discussion

Architecture

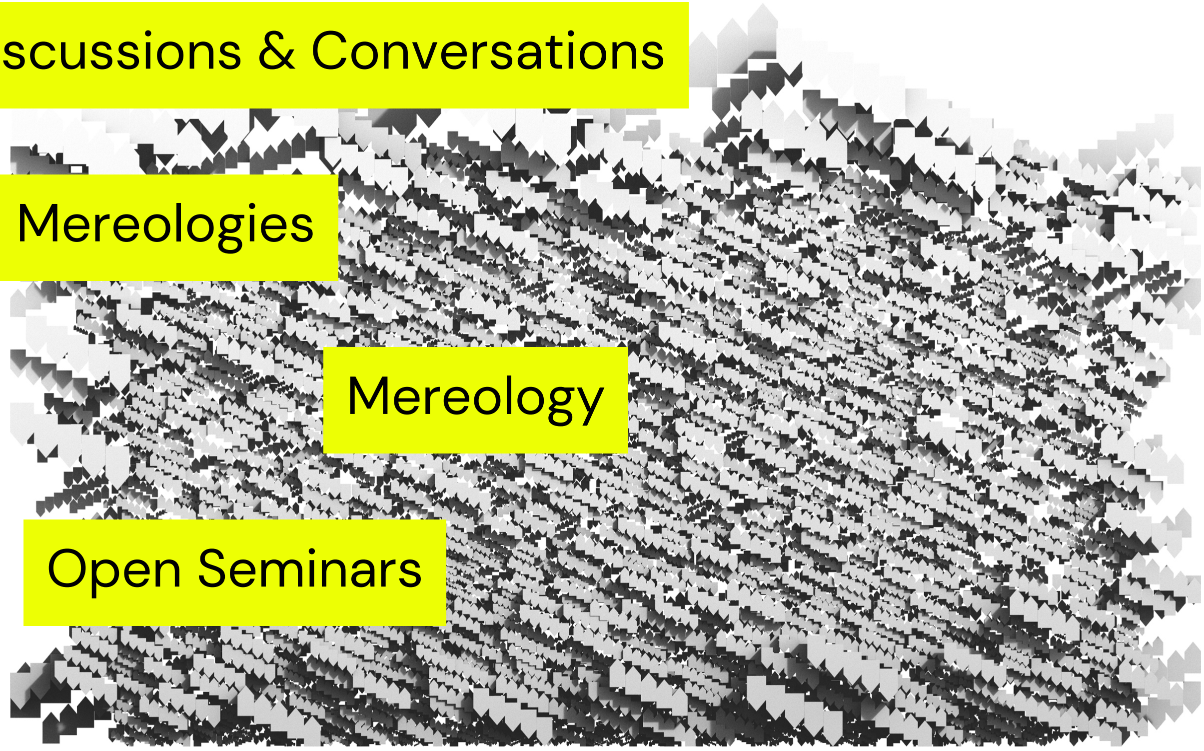
Composition

Discussions & Conversations

Mereologies

Mereology

Open Seminars



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Participants: Emmanuelle Chiappone-Piriou, Jose Sanchez, Casey Rehm, Jordi Vivaldi, David Rozas, Giorgio Lando, Daniel Koehler with questions from the audience including Mario Carpo and Philippe Morel.

Daniel Koehler: The talks of the symposium were diverse and rich but also abstract, and intentionally external to architecture. At such a point it can be asked if, how, and what role Mereologies can play in architecture? For the discussion we are joined by additional architects with unique angles on composition and part-thinking in their work. Casey Rehm, a computational designer, Jose Sanchez, who is working actively with digital models of participation and Emmanuelle Chiappone-Piriou, an ecological thinker, experienced in the history of architecture.

José Sanchez: My first reaction to the presentations is controversial. I think it presents well much of the work that is happening in architecture at the moment showing an interest in Mereology and discrete architecture. However, looking at the issue of parts is fundamentally a project where the idea of composition and the idea of structure is relevant as well. Patterns organised by parts can potentially deal with different forms of value. So, in a way, I find a surprising rejection in some of the ideas.
Mereology seems to be giving us a framework for many different positions to coexist, and I think that we did an excellent presentation of a much clearer advocacy for a form of relations that we might desire that has to do with pre-production, more like an agnostic framework that allows to give us a vocabulary. Are we interested in having advocacy, in having that intentionality, or are we more interested in what the ontology should be or the framework that we are going to work in?

Daniel: I have learnt something from Giorgio's book that when we define Mereology, it comes in different notions and ranges. On the one hand, you can see it as a distinct theory, as a specific project that has its own agenda. But also, and more crucial in the first place: you can take Mereology as a larger framework to talk about the relations of parts to wholes – simply compositions. OK, but you might ask: why don't we use the term composition directly? Because, composition has a specific connotation in architecture and refers to the Ecole des Beaux Arts, classical means of relating objects. It was rejected by the Bauhaus, which promoted a different form of composition with modern means. We could continue this through the history of architecture. In architecture, composition is a specific style but not a history. How could we compare those different modes of architectural composition? Can we think of something parallel to morphology or typology which would allow us to compare a plurality of relations between parts and wholes without defending a certain style? When the formal readings of parts turn into their own project, it might be quite valuable that one can figure a figuration without predefining its value by imposing a structure. That might be Mereology as a project. But first of all, the question is how can we intentionally speak about parts? That would be Mereology as a methodology.

Giorgio Lando: I agree with Daniel that it is very important to distinguish various ways in which the word "Mereology" can be legitimately meant. In particular, the word "Mereology" stands in some cases for a specific theory of parthood and composition, and this theory may be such that structure has a role in it, or such that structure has no role in it. A historically important kind of mereological theory, Classical Mereology, is of the latter kind: it is deliberately blind to structure in providing existence and identity conditions for complex entities. In other cases, however, the word "Mereology" stands for an entire field of research, within which competing theories disagree about the role which structure should – or should not – play. If Mereology is seen as a field of research, then it is misleading to say that structure plays no role in it. This equivocation may explain some of José's perplexities.
However, some other perplexities are likely to persist even once we disambiguate the word "Mereology", and we focus on Classical Mereology. Classical Mereology indeed includes some highly counterintuitive principles, and the usual reaction of the layman to these principles is to dismiss them rather quickly. For example, it might seem prima facie incredible that the order of the parts of something does not matter for the identity conditions of complex entities. However, this quick dismissal is usually determined by an equivocation: what is actually incredible is that the order of the parts of a building, or of a village, or of a car does not matter for its nature, for what that building, that village or that car is. However, this is not what Classical Mereology claims. What Classical Mereology claims is weaker and more reasonable: it says that the order of the parts does not matter for the identity conditions of complex entities, such as buildings, villages and cars.

According to Classical Mereology, it never happens that there are two distinct entities which only differ because of their structure. Classical Mereology is not committed to the frankly incredible claim that structure has no impact on the nature of complex entities, but only to the more reasonable claim that complex entities are never distinct only in virtue of their structure.

Moreover, this claim of Classical Mereology is restricted to single concrete entities. This might make the confrontation between Classical Mereology and other disciplines, such as architecture, troublesome, inasmuch as these disciplines are more interested in abstract types than in concrete tokens, more interested in repeatable entities than in their single, concrete instantiations. As far as I understand, when architects speak about the parts of a building or of a city, in most cases they are not speaking about a single piece of material and the way in which it is composed, but about a type of building and the fact that there are different types of buildings which result from the combination of the same types of architectural elements, differently combined.

Once you move from this level of types and abstract entities to the level of concrete entities, the claim of Classical Mereology that structure has no role in the identity conditions of complex entities is much less incredible: consider a single, concrete building (not a type of a building) in a certain moment in time. In that moment, its parts are structured only in one way: the parts of a single, concrete building cannot be structured in two different ways at the same time.

Architects might legitimately retort that architecture is about repeatable types of buildings, about projects which can be applied several times. Given this approach, Classical Mereology is probably not the best tool for modelling repeatable types, and it is indeed desirable to look at different theories, which are not deliberately blind to structure. Mathematics is full of tools which can be employed to this purpose, including set theory and various kinds of algebras. Architects may legitimately wonder why philosophers focus on Classical Mereology instead, which is a serious candidate for the role of sound and exhaustive theory of parthood and composition for single concrete entities, but not for abstract types. The reason is probably a sort of deep-seated philosophical skepticism towards abstract entities, and the idea that fundamental reality consists of concrete entities, while abstract entities are less fundamental, or even a mere construct of the human mind.list or minimalistic inclinations

However, it is not the case that *all* the philosophers working on Mereology endorse the claims of Classical Mereology. In particular, in the literature of the last ten years, many prominent philosophers (such as Karen Bennett, Aaron Cotnoir and Katherine Hawley) have by contrast argued that Classical Mereology is completely misguided, and that we should also pay attention to structure within the realm of concrete entities**.** In my book I have defended the claim that, by contrast, Classical Mereology is a perfectly adequate theory of parthood and composition for concrete entities, but many other mereologists disagree with me. More in general, there is virtually no claim about parthood and philosophy about which every philosopher agrees!

Mario Carpo: Giorgio, you have said that at some point Mereology merges with set theory. What exactly is here the overlay or intersection between Mereology and set theory? In reverse, where is Mereology separating itself from set theory, and where are the core differences?

Emmanuelle Chiappone-Piriou: Is there any way that relates Mereology to category theory?

Giorgio: For what concerns the relation between set theory and Classical Mereology (which, as we have seen, is a specific theory, which is mainly designed to characterise the realm of concrete entities and the way in which they are part one of another), the deepest difference consists in the transitivity of the relation: the relation of parthood in Classical Mereology is transitive, while the relation of elementhood in set theory is not transitive. Thus, if a first entity is part of a second entity and the second entity is part of a third entity, then – according to Classical Mereology – the first entity is part of the third entity. By contrast, it can happen that something is an element of a set, which in turn is an element of a second set, while that something is not an element of the second set. Sets are stratified: you have typically sets of sets of sets. In Classical Mereology, as a consequence of the transitivity of parthood, there are no stratified complex entities.
While there are many interesting ties between set theory and Mereology, I am unaware of any connection between Mereology and category theory.

Mario: Can you give us maybe an example, like three inclusions in set theory and three inclusions in Mereology?

Giorgio: Consider the set of Italians. I am a member of this set. The set of Italians is also a member of the set of European people. However, I am not a member of this latter set, inasmuch as I am not a European people (I am not a people at all!). We thereby obtain a failure of transitivity of elementhood among sets. Nothing similar is admitted by Classical Mereology: I am part of the fusion of Italians, the fusion of Italians is part of the fusion of Europeans, and I am part of the fusion of Europeans as well.

Mario: So, in set theory, these don't happen?

Giorgio: It does not happen in the sense that it does not always happen. There are indeed cases in which the same elements appear at different levels of the set-theoretical hierarchy, but this does not happen in general, and is not warranted by any principle of set theory. There are actually many varieties of set Theory, but in no variety of set Theory is elementhood transitive.

Philippe Morel: My feeling is that Mereology is a matter of "technicalities" about a relationship that exists in set theory. If you look at the inclusion as the property you are also looking for in Mereology, I don't really get what Mereology brings on top of the purely mathematical "canonical" set theory. It gives me the feeling that Mereology is foremost a way (or a "trick") for philosophers to take control of a theory that escapes them because it is a fully mathematical theory... So, this is why I have a bit of a problem with this notion because again, technically speaking, I still can't make a clear distinction between the philosophical property and the mathematical property. It is like a layer of metaphysics that is brought on top of the mathematical theory and of course I can't consider this as a great addition. My second issue is more of a general remark. Why don't you speak about relational databases like SQL databases? At some point, to my understanding, it is a very practical implementation of what describes Mereology, because it is all about belonging, etc.
Though, I find the mereological approach interesting, especially if it prevents a reintroduction of composition, as I see a danger of bringing back this concept of composition in architectural discourse.

Giorgio: You are right: set-theoretical inclusion (i.e., the relation of being a subset) has precisely the same formal feature of mereological parthood. However, set-theoretical inclusion is not the fundamental relation of set theory: it is definable in terms of set-theoretical elementhood, while set-theoretical elementhood is not definable in terms of set-theoretical

inclusion. Thus, the fundamental relation of set theory is elementhood and is not transitive, while the fundamental relation of Classical Mereology is parthood, which is transitive.
There have been several attempts (for example in *Parts of Classes*, a book by David Lewis) to exploit the formal analogy between mereological parthood and set-theoretical inclusion in order to reduce set theory to Classical Mereology. The biggest obstacle for this project are set-theoretical singletons, *i.e.* sets with a single element. The relation between these single elements and their singletons is not easily reducible to Mereology: it is a kind of brute stratification (a form of structure), which has no place in Classical Mereology.
I agree with Philippe's remark that Classical Mereology is nowadays a mathematically uninteresting theory, in spite of the fact that it has been originally elaborated by great mathematicians such as Stanisław Leśniewski and Alfred Tarski: it is simply a complete algebra without a zero object. The reason why philosophers discuss Classical Mereology does not depend on its alleged mathematical originality: some philosophers (including me) think that this very simple and unoriginal mathematical theory is the sound and complete theory of parthood and composition, at least in the realm of concrete entities. Thus, the reason to be interested in Classical Mereology is not its mathematical originality, but its plausible correspondence with the way in which parthood and composition really work.
As far as datasets are concerned, I think that it is *prima facie* preferable to construe them as sets rather than as mereological wholes. Indeed, the distinction between inclusion and elementhood is pivotal for datasets. This distinction characterises set theory, while there is no analogous distinction in Classical Mereology.

Daniel: I would like to extend on Giorgio's point that Mereology offers mathematically an algebra without a zero object. Mereology starts with individuals without defining a set in the first place. In Mereology, you can't have an empty set, a null set, a zero object. You can't have a building without building parts. You need parts for thinking a building. This will become more dominant in future because with higher computing capabilities we are able to compute more and more without the need of abstract models. Take as an example the Internet of Things: a building environment where every building part has sensors and is connected. That means that very literally building parts can talk with each other. Such

a building environment also participates, and will offer its own economy. Here, value begins with a building part as an active participant in the market. Already in daily BIM practice it is impossible to think of a building without its parts. So, we should also stop thinking of buildings as predefined sets.
To my understanding, a database is constructed on a very specific ontological worldview. Today's databases take Composition-as-Identity. This principle says that everything is included in the distribution of data points. Nothing above the distribution of atoms exists, not any compound meaning. Whereas, compounds are fundamental to architecture. Just think of a typology; you can't reduce a façade to windows. What does a courtyard actually exist of? This of course does not relate to math but to philosophy. It is controversial, otherwise it would not be philosophical. Every building is controversy, or call it multiplicitous, because architecture is pre-logical in a sense. We can't reduce architecture to math. It is also the point where the discussions on beauty depart in architecture. With ease you can describe a building in the first instance through the distribution of its cells. You can describe a housing project just through the part-relation of a shared wall between two flats only. But how do you describe the mountain which Moshe Safdie designed by stitching together the shared walls of flats in such a way that their roofs turn into terraces? Architecture starts where it exceeds simplicity. Yes, we can design buildings with the use of databases with ease. We are able today to compute buildings without structures. But where are their compound meanings? It will be fundamental to find a way to compute what is common, what is collective between the parts. Therefore, I think we should be suspicious of databases or any kind of structural models which were thought without any compound meaning, so to say, without architecture in the first place.

Jose: I'll re-bring some of the points that Jordi made to the conversation. Jordi, you brought up Graham Harman's concept of a radical present. I find it kind of controversial that it seems to eradicate a form of speculation, a form of potential, a form of endless abstractness. If we're moving from the classic Mereology towards a more abstract sense, I think that a lot of architecture production that we discuss especially with discrete projects – that has to do with parts – has to do with potential encounters of entities in that list and is not purely defined by the actual instantiation of the actual encounter of entities. So, we evaluate and design, also thinking that encounters might never happen. So, under the umbrella of that radical present, I wonder what do you see in them?

Jordi Vivaldi Piera: I would say that the term “potential” is misleading. Its meaning generally refers to its capacity to produce other realities, but at the same time it undermines the possibility of novelty because it assumes that an object already contains what it will become. In this sense, I emphasise radical presence in order to understand which object’s “actualities” permit the production of novelty, rather than understanding which are the hypothetical novelties that it contains and therefore at the same time undermines. In this sense, I interpret potentiality as a particular type of actuality.

Casey: I was interested in Daniel’s point; it reminds me of a recent article by Luciana Parisi called “Reprogramming Decisionism”, where she’s talking about machine learning, neural networks and that these technologies in essence assemble. With this, fact is accumulated, which says that something is probably something else. I’m interested in this relative to Mereology and also the statement that a human deals with abstraction but a machine deals with simple facts. How does the mereological project deal with probability? Is that something probably something rather than not? How does the part, certainly something like, you know, the models that you have shown us rely on clear logic? As I nearly understood there is a kind of model that you’re describing, but *h*ow does Mereology deal with improbability? I think it is also something that is going to face the design profession in relationship to the kinds of machines which deal with things.

Giorgio: As far as probability is concerned, I do not envisage any specific, direct problem stemming from the interaction of probability and Mereology. A mereological claim can have a certain degree of probability, and the probability at stake can be either objective/statistical or subjective. In neither case are there specific problems: mereological claims are, from this viewpoint, on a par with other claims.
While probability is not directly troublesome, there are some potential problems in the vicinity: Classical Mereology does not countenance the hypothesis that an entity is part of another, but only at a certain degree. Consider a cloud in the sky: the water molecules in the centre of the cloud are definitely parts of the cloud, and the molecules far away from the cloud definitely are not parts of the cloud. However, there seems to

be a grey zone of molecules, which are neither definitely within the cloud nor definitely out of it.
These scenarios can be treated in various ways, and the approach depends on the adoption of a certain theory of vagueness. According to the so-called epistemic theory of vagueness (set forth for example by Timothy Williamson), the fact that we are unable to identify the boundaries of a cloud depends on our epistemic limitations (we are unable to identify the boundaries of the cloud, but this does not show that the cloud has in itself no definite boundaries). According to the semantic theory of vagueness (in the version adopted for example by David Lewis), there are actually myriads of clouds and each cloud has precise boundaries; however, our discourses about the cloud are semantically underdetermined, inasmuch as we have not decided which among the myriads of clouds in the sky we are speaking about. Both the epistemic theory of vagueness and the semantic theory of vagueness are perfectly compatible with Classical Mereology, because they locate vagueness in our language or in our epistemic practices and not in reality: in reality, given two entities, either the former definitely is part of the latter, or the former definitely is not part of the latter.
However, recently also the so-called ontological theory of vagueness (Michael Tye is one of the most ardent advocates of this approach to vagueness) has gained some traction. According to the ontological theory of vagueness, vagueness is in reality, and this happens also in the mereological case of the cloud: the molecules at the periphery of the cloud are neither definitely parts nor definitely non-parts of the cloud. The adoption of the ontological theory of vagueness indeed requires a revision of Classical Mereology. According to Classical Mereology, for example, two complex entities are identical if and only if they have the same proper parts (the proper parts of something are those parts of it which are not identical to it): but this principle is not applicable to entities which have no definite domain of proper parts. According to the ontological theory of vagueness, this is what happens in the case of the clouds and in similar cases. To sum up: probability and various theories of vagueness (such as the epistemic theory and the semantic theory) do not require any departure from Classical Mereology; only the ontological theory of vagueness requires a departure.

Emmanuelle: It appears we are navigating and combining different sets of discourses that may or may not be consistent with one another, nor with

Mereology as it appears here to be merge into a compositional paradigm: we are simultaneously addressing materiality and formal systems, social coherences and principles of governance, all at once.
I believe that, as in the 1950s and 1960s, architecture faces the risk of talking itself into an impasse, by resorting to certain languages and positions that may induce, and reproduce, a reification of social patterns. In this context I often think of a remark from Michel Ragon, the French architecture critic who wrote about and promoted experimental architecture in the 1960s. Looking back at those projects, twenty years later, he asked himself how a "life-like" macro-structure could be designed in advance, and if it could be designed at all, considering life is "rightly made of chance and unpredictability". This remains a valid and important question, which is updated by our resort to instruments that allow us to think of, and manipulate, the world in terms of particles and parts. Quantum physics teaches us that there is irreducible uncertainty in our physical existence, an inherent contingency, and that there is a fundamental limit of precision with which you can actually measure a particle, hence a limit to the precision with which you can grasp the world. How is it that this uncertainty can be taken into account when dealing with matter or with information; and, when dealing with parts, how can we do so without first defining them? How can we account for interactions and relationality? How is it that we can account for change, for performance and transformation, all at once?
This brings me to a second point that stems from this a priori impossibility to capture the image of life without "to some extent captur[ing] life itself" (Ragon). I understand that Mereology makes a claim for exhaustibility and generality. But what if we take this claim into the architectural project? Do we think that we can actually design a system, a structure or a whole whose formal principles allow for it to be exhaustive? Following Gödel, I understand that you either have exhaustibility or consistency, but not both.

Mario: Can I go back to the branch of theoretical philosophy to cover things? We more or less know why we in the design profession became interested in particles, and the relation between particles, in recent years. It seems he (Daniel) came across the term Mereology. He hijacked it and imported it into the architectural discourse. Like we always do. We take a more refined tool which comes from another discipline, and then we appropriate it and give it another meaning which means nothing to you

(Giorgio). This we have been doing for a long time. This part of the story we know. The part of the story that we don't know, that you can tell us in two lines is, does this happen with Mereology? Can you give us an outline of the history of analysis of Mereology in contemporary philosophical discourse? Because when I was a student nobody mentioned Mereology, and now everyone does? When did that happen? Where does this come from? And from a distance, from a critical point of view, why is it that you right now are talking about Mereology while many years ago nobody talked about it?

Giorgio: The word 'Mereology' is rather new and was made relatively popular by Stanisław Leśniewski at the beginning of the 20th century (according to Leśniewski, Mereology was more properly a branch of logic). However, philosophers (and in particular metaphysicians) have always used the notion of part and set forth theories about it. Plato's theory of parthood has been recently analysed and defended by Verity Harte, while Aristotle's theory of parthood is considered by several neo-Aristotelian metaphysicians a viable option in the contemporary mereological debate.

Mario: But, in math, there are fractions, proportions, modularity. These are all today discussed as mereological questions.

Giorgio: An important difference between many past theories of parthood (in particular in Ancient and Medieval philosophy) and contemporary Mereology concerns the expected domain of application: Plato, Aristotle, Abelard and Ockham were for example mainly interested in the parthood relation which connects a property with an individual instantiating those properties, or two properties one with another. These instances of parthood were important within metaphysics itself, for example when a theory of ideas or universals was elaborated. By contrast, contemporary Mereology is more focused on the concrete, spatio-temporal parts of concrete entities.
However, no matter what the original domain of application of the parthood relation was, the theories of parthood became progressively more abstract and formal: in some works of Leibniz (17th century), for example, it is possible to find a formally complex and highly abstract theory of parthood, whose principles are expected to hold irrespective of the domain of application. This is also the case of the theory of parthood developed by Bernard Bolzano in the 19th century. Thus, in spite of the

fact that the word 'Mereology' became popular only in the 20th century, contemporary Mereology has solid roots in the history of philosophy. Nonetheless, it is true that – for example – forty years ago Mereology was much less popular than nowadays. This may have depended on the alternating fortunes of metaphysics (the wider branch of philosophy to which Mereology belongs) in analytic philosophy. Forty years ago analytic philosophers, in continuity with logical positivism, often despised metaphysics as an obsolete leftover from the past. This has changed dramatically in the later decades, thanks to the influence of thinkers such as David Lewis and Saul Kripke, and metaphysics is now back at the centre stage of contemporary analytic philosophy. The renewed popularity of Mereology is an aspect of the renewed popularity of metaphysics in general. This also depends on the fact that contemporary metaphysicians often attach great importance to the concepts of existence and identity. Classical Mereology has the ambition to provide existence and identity conditions for every complex entity. This makes Classical Mereology highly interesting for contemporary metaphysicians.

Philippe: Let's make a comparison with the discipline of architecture. In architecture, this last trend could be compared to what happened with Christopher Alexander, or before with Mies and then Peter Eisenman. The challenge for me is that I don't consider Mereology an uninteresting philosophy in architecture, I just see it as a highly modernist theory.
My question is the following. According to you (Giorgio), in the field of philosophy, do you consider Mereology as a modernist philosophical trend or something that has nothing to do with philosophical modernism? Because in architecture, my feeling is that it directly corresponds to a highly modernist attitude, and the fact is that this modernist attitude is highly reductionist. It is defining what is the most elemental aspect of things, so it's pure reductionism, and it's still based on some concept of – maybe not order, but at least some attempt at bringing order into things (though sometimes "unpredictable order").
For me, that is super modernist and my feeling is that we are living in a world built on this reductionist modernity. Right after this reduction – and we already had it in some form a hundred years ago –, let's say after 1950 we were already going into the opposite direction: an explosion of models… That one is now based on statistical methods, on big data, as related by Mario in his book. So again, I'm not saying Mereology can't be an important or at least a useful platform for debate, I am just wondering

about the inherent nostalgia of going backward in the ordering of reality – in History. Maybe we can – and should – just accept absolute chaos and trillions of trillions of terabytes of data as a fact, *without trying to put some order into that*. So, my question finally on a purely philosophical level is: do you consider Mereology as modernist, or maybe as a new modern or late modern philosophical theory, or as something which has nothing to do with that?

Giorgio: There is indeed a modernist component in Mereology: the deliberate blindness to structure, which characterises Classical Mereology, is motivated by a form of "taste for desert landscapes", which in turn might be seen as the outcome of a modernist appetite for order. However, it should also be considered that Classical Mereology includes either as an axiom or as a theorem (according to the way in which Classical Mereology is axiomatised) the principle of Unrestricted Composition, according to which – given some entities, no matter how sparse and gerrymandered they are – they compose something. Due to Unrestricted Composition, Classical Mereology is committed to the existence of all sorts of awkward entities, such as the fusion of my left arm, Barack Obama's nose and the Great Pyramid of Giza!
On the other hand, a rather "modernist" thesis, which is often associated with Classical Mereology, is the thesis of Composition as Identity. According to the thesis of Composition as Identity, any whole is strictly speaking identical to its parts and is – so to say – no addition to being, with respect to them. This mereological thesis is expected to warrant a form of ontological economy, and can be seen, as a consequence, as the outcome of an appetite for order.
However, Composition as Identity is not derivable from Classical Mereology, and is a highly problematic thesis in itself. A whole (for example, a chair) and its parts (the four legs, the back and the seat) are mutually discernible, inasmuch as – for example – the chair is one entity, while the four legs, the back and the seat are six entities. If they are discernible (i.e., if they have different properties), then it is not easy to make sense of the claim (entailed by Composition as Identity) that they are identical.

Casey: I think you have covered everything I want to say. Based on this I don't think there is anything suggestively reductive about composition. I think that it is a ridiculous idea that unrestricted composition suggests that this property could be part of something.

My colleague Daniel is doing the mereological project, but it is certainly nothing reductive. I think it's more that there is a very explicitness and straightforwardness about the roles and function of the thing, i.e. the function isn't the exclusive part of the composition, especially according to the kind of lectures we saw today.

Mario: I have a suspicion. I see one main point of this symposium is that in the theory of parts of today's computation the parts we are dealing with are new in the history of architecture theory because they don't need rules of application. These parts are different from Alberti's or Eisenman's because for the first time ever in the history of humankind or the history of design we can deal with parts without any rules or orders in them whether it is proportions, fractions, modules, geometrical symmetry, proportional symmetry, etc.
In the history of design, all these tricks and tools were needed to make sense out of parthood. We had to invent structures, like reductionism or data compression, to put some order into the chaos generated by the random accumulation of parts–to make order out of chaos; to manage parts in a "rational", ie intelligible way: a way that made sense for the limited data-management skills of our own mind. And now for the first time ever in many practical instances we are getting particles just as they are. We can put them flat on the table and each one of them stands, and that is all that we need. This the nobility of the parts that you're dealing with. This is the novelty: parts without anthropocentric reduction and human-made intelligibility.

Casey: Do you say that there are no rules for these parts or is it just that the rules are inherited in the parts and not applied to the total? I'm suspicious of saying that (the former) in dealing with parts. And again, we still have rules because we have generated something that is mereological. There are still rules but the rules are in the parts rather than trying to be imposed on them. And so actually, it is just where the rules are located in the design process.

Mario: There must be rules of some sort somewhere, but the main difference, and again, I follow my suspicion, we no longer need rules to manage the accumulation of parts beyond the limit of computational (ie machinic) retrieval. We don't need to structure them in symmetrical parthood or any other strategy for part retrieval. We always needed some superposition over the structure to reduce the complexity of what was so big that we couldn’t deal with it. Now when dealing with something so big, we can just let the machines deal with it. The generation process must have some rules somewhere, but my suspicion is these are no longer needed for any practical human purpose. Now we are capable of managing any messy random heap of disconnected parts–because if fact we don’t have to deal with that mess any more: we have machine to do it in our stead.

Emmanuelle: One simple question would be: what kind of parts are we dealing with? Are they not themselves wholes composed of other parts, entering into larger or different wholes? Are we talking solely about human-made parts, which designers can generate, craft and master, or we are considering opening up these wholes to other domains; thus, to what degree and within which limit are they potentially extendable?
You’ll excuse me for coming back to my previous point, regarding the notion of uncertainty and how it can be taken into account, and let’s hypothesise the wholes we consider are governmental ensembles. The researcher in philosophy of law Antoinette Rouvroy identifies how uncertainty and unpredictability are systematically considered as risk. She analyses how the cybernetic and algorithmic order that underlie our contemporary forms of governance attempt to systematically and preemptively tackle risk in order to eradicate it. On the other side, there is a reverse relationship to risk that, against risk management, consists in exploiting it and profiting from it, as you can see in high frequency trading. Risk here appears to be the motor of speculation, it plays with the asymmetric distribution of information within a system.
But if you consider chance, and hence uncertainty and unpredictability, as being not epistemic – as in both aforementioned cases – but objective, and furthermore, if you consider it to be at the source of all life in the biosphere – as Biology Nobel Prize Jacques Monod showed – how can it be taken into account and integrated in the elaboration of hybrid parts and wholes? Embracing this objectivity could allow us to conceptualise a commonality based on an open, decentralised notion of whole that is not subjected to social constructivism.

Giorgio: I owe an answer to Emmanuelle about unpredictability. Unpredictability can be either an epistemic phenomenon (it happens when some human subjects are de facto unable to foresee how things will go, and their inability to do so might be due to their contingent cognitive limitations), or a metaphysical phenomenon (there is

metaphysical unpredictability when something is objectively indeterminate, independently of any fact concerning human subjects). If unpredictability is seen as an epistemic phenomenon, then it does not require any modification of Mereology: the fact that some human subjects are unable to determine whether *x* is part of *y* has no impact on the circumstance whether objectively *x* is part of *y*.
The philosophical consequences of quantum indeterminacy are hard to interpret: according to some interpretations, it is indeed a kind of objective, metaphysical indeterminacy. However, as far as I can see, quantum indeterminacy does not concern mereological relations. Thus, it seems to me that neither epistemic nor metaphysical unpredictability have any specific bearing on Mereology.

Daniel: Unpredicted and indeterminant like a good building, it seems to me that Emmanuelle and Giorgio overcame the boundaries of the round table. I would like to use the moment to thank you all for your insights, contributions, and round up the discussion with an open ending.

Article 8 : Friendly Architecture — In the Footsteps of Structuralism – An Interview with Herman Hertzberger

Architecture
Architecture Theory
City Architecture
Mereologies
Mereology
Urban Design

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This interview took place on April 11th, 2017 at the office of Herman Hertzberger in Amsterdam, with questions by Daniel Koehler.

Daniel Koehler: After all your years as a teacher, maybe it would be a good departure for conversation if you can tell us what is your favourite exercise for teaching architecture?

Herman Hertzberger: Well, my favourite exercise is making a housing environment, where small children could live and play outside. This is an old-fashioned thing, but I am absolutely convinced that children should play in the streets in order to find out about the world and to learn about the good and the bad things that exist. I am afraid that today in urbanism you find high-rises, and the immense distance from the living unit to the street is a problem. Consequently, cities only have playgrounds with fences around, and there children are safe to play. But the world is not only about safety, the world is about finding out how far you can go in your life.

Can you tell us a little bit about how you began to communicate as a group during the beginning of structuralism?

We started a school! We had seminars for discussion, where everyone brought in something to discuss. And then we had the *Forum* editorial staff. There was Aldo van Eyck, Jacob Bakema and others who are less well known (Dick Apon, Joop Hardy, Jurriaan Schrofer and Gert Boon). There was an enormous amount of communication. Every Tuesday night we saw each other with no exception, where we discussed the next issue of the magazine.

And, what was the relevant media at the time you started to develop your ideas?

Magazines were very important. We used to have three or four Dutch magazines, two French, two English, one American, two Swiss, two Italian. They were all on the table. “Did you see that building? I think it is good.” And then we had a discussion. Today we still get some magazines, but today you get all the information from around the world in one click. That is fantastic, the possibilities today are just immense. It is more information, a lot of pieces of an enormous puzzle. But is it also possible to put it together? I hope the younger generation can.

The magazine *Forum* was for me a sort of postgraduate study. At that moment I started to see the work, the hands and eyes of real architects. That helped me to start thinking. And there were connections to many other architects from all over. There were conferences, and there you saw people. At Delft University, where I was teaching, we invited all the architects we were interested in. We are still doing this.

When one reads the current literature, one can draw two different issues. On the one hand a common critique of functionalism in architecture, and on the other hand, the influence of new ideas coming from sociology. Would you say that this enormous explosion of ideas and diversity of projects was a response to architectural problems or were these new concepts coming from other fields prescriptive to your projects?

First of all, there is nothing coming from sociology. I have little or no connection to sociology. Sociology is the science of human relations. But you do not need to go into this science as an architect. Architecture is a matter of using your eyes and ears to look into the world and see what needs to be done. But today, architecture is driven by algorithms and rules. All the rules, saying you should do this or that, you are supposed to not do this. Architecture is then reduced to problem-solving. You must be aware of that mistake. Architecture is not problem-solving. Of course, you have to solve problems, but this is only one aspect of architecture. It starts to be architecture when it provides more freedom to people, opening the possibility that things are getting better than they were before.

Can you give an example?

A dwelling needs to have a balcony. Why? To let people go outside, and there are rules about the size of your balcony. Most architects think: well, I included a balcony. But they should base the form and dimensions of a balcony on the needs of daily life. Such as sitting in a corner without being seen by others or not being disturbed while reading your book yet with the possibility of having contact with your neighbour. Second, you may want to be able to have a meal with your family. You maybe want to have flowers and plants. In a way, this is culture. Make that list, and when you design a balcony, be sure that all the points you have listed have also been fulfilled. In this way you increase people's freedom. Most balconies do not do that. On most balconies all you can do is sit. Most architects don't think, they don't look at what is going on. And then, of course, the developer says, "It should not cost more, so we have to make it small." So I have rules independent of the developers. For me, it starts to become good when those rules are going to be met. This method works for every part of the building, from a dwelling, to a living unit, to a street, to the school. In a school, you can design where the black board in a classroom is going to be. And you have to think about what a school might be. I don't need sociologists for that. Sometimes, sociologists can tell you some interesting things, but you have to think, and in the first place, look for yourself.

Your communal spaces are famous for their human scale, like the doorstep. I think that this down-scaling of the city to elements of a building enables you to design the building as an open system. For me, it seems you draw a difference in creating a building as a building and designing a building as a city.

For me, city, architecture, and building are very much related. Aldo van Eyck believed that making architecture is always making things more inside than before. Aldo van Eyck said, "Whatever you do, it is supposed to always increase the inside quality." When you want to go outside, you go to the fields. There you have the horizon, you have the clouds and the openness. A city is for exchange – exchange of goods, of ideas. Cities are mostly based on trade, and on having a cinema, having shops, having communal things, being together.
Aldo van Eyck also claimed that the city should be a big house. I thinkthat is a dangerous thing to say because the city is not the house whereyou are yourself, or where you are enclosed. The city should never be enclosed but always open, in connection with the whole world. It is the place where you see the airplanes flying above you. But it is an inside space in relation to the open field. And a building is, in fact, a small city. Make a building as a small city to have the emphasis lay on communication and exchange.
But most buildings are private territories with public corridors. How narrow can a public corridor be? It cannot be a centimetre larger,because this would cost money. Means of communication are consideredextra. You can sell the dwellings but not the corridors. As a result, mostbuildings have very beautiful apartments and very small corridors. I ampleading for buildings where the corridors are streets. I try to put moreemphasis on the communal spaces in a building.

When you consider a building as an open system, what role does the boundary between inside and outside have? Do you think that these open systems have an outside or do you think of them as endless? What is their relationship to the context and environment?

City is not just buildings but the space in between the buildings as well. The edge of building is forming the space of the city. You have to conceive of the edge of a building not as an end where the outside starts. You must see it the other way around, as a wall in the interior space of the city. The idea of the building as city is to put buildings in such a relation that the space in-between them is as important. This is something that is completely lost. It is also considered nostalgic. But look to New York. In New York, you have these high skyscrapers, but you also have very nice streets. When I am in Manhattan, I feel quite enclosed. That is because of the very strict system of the grid, and the building lines by which the streets are defined, and the blocks in between are open.

In one of your articles [Open City, 2011], you rightly point out that most of today's housing projects consciously exclude communal spaces, and focus only on the assembly of private areas without any spatial linkages between them. Private areas are protected to one another rather than connected. A common – and I think dangerous – justification for such a design refers to changed economic circumstances, and most cynically, to the death of the welfare state. Would you say architecture is so dependent on economics?

Every square meter is supposed to generate a fee, so public space will be reduced to a minimum. Architecture has become business. And that makes the position of the architects to contribute to better spaces and towns very difficult.

But then architects are even more important.

Important as long as you are able to be aware of what sort of culture you are living in. I cannot give you the answer what to do. You have to explain and fight. But you need clients who believe in the architect. Things are very materialistic today. But there are also very interesting initiatives. For example, in Rotterdam, you have these old industrial halls which could be reused without high costs. Add a little paint, and it works. There are ways today that are contradicting this idea of architecture as economics. There is a lot for you to invent.

When I told a friend that we will visit you as one of the main protagonists of structuralism, his response was: 'Wait a moment! Herman Hertzberger is not a structuralist; he is a humanist.'

Can you not be a structuralist and a humanist at the same time? Is this contradictory?

I think what my friend was pointing at is that there is a difference between structuralism as a style and structuralism as modus operandi, as a form of organisation and composition.

Style has to do with aesthetics, but aesthetics is a pitfall. Most architects think making something beautiful is all that architecture is about. But you can't make something beautiful, it is impossible. That doesn't work. What you can do is make a painting which is striking, and shows you something

you never saw before that makes you happy or fall in love with the painting, and then we decide this is a beautiful painting. But in architecture, don't spend energy on trying to make something beautiful. Make it work. Then you may hope that someone says this is beautiful. For instance, the composer of music Arnold Schönberg said, "Do not do what others consider beautiful, but just what is necessary to you." I like a building because it works. When someone if I think it is beautiful, then I say, when you are in love it is going to be beautiful. Beauty comes as a result. But you cannot say, now I am going to make it beautiful. Beauty is a pitfall for architects.
Structuralism means there are simple rules that enlarge the amount of free space that you can achieve. I took the grid as an example earlier. The very rigid system of the grid allows you to be more free in the blocks in between. All of the blocks can be different; some high, some low. It is an enormous mosaic of possibilities that is held together by the grid. When you know what rules you have to use, you can be creative. It is a misunderstanding that the one contradicts the other.

It is interesting that you describe a rule as a form of enclosure, as a form of an inside.

If something is not limited you create chaos. Rules prevent you from chaos, and within rules you can be creative. Noam Chomsky [the linguist] uses the words competence and performance. The structure of language is its competence, it is its capacity to express. And performance is what you are actually expressing with it. In language you have grammar, but every individual talks in his or her personal way using the same rules.

Would you say that you have a grammar and vocabulary then? Do you have certain elements that you are frequently using? You were talking earlier about balconies and streets. In your work do you consider elements repeat structurally, which can re-emerge in different styles, but with similar performance? Or do you begin each project with a new grammar?

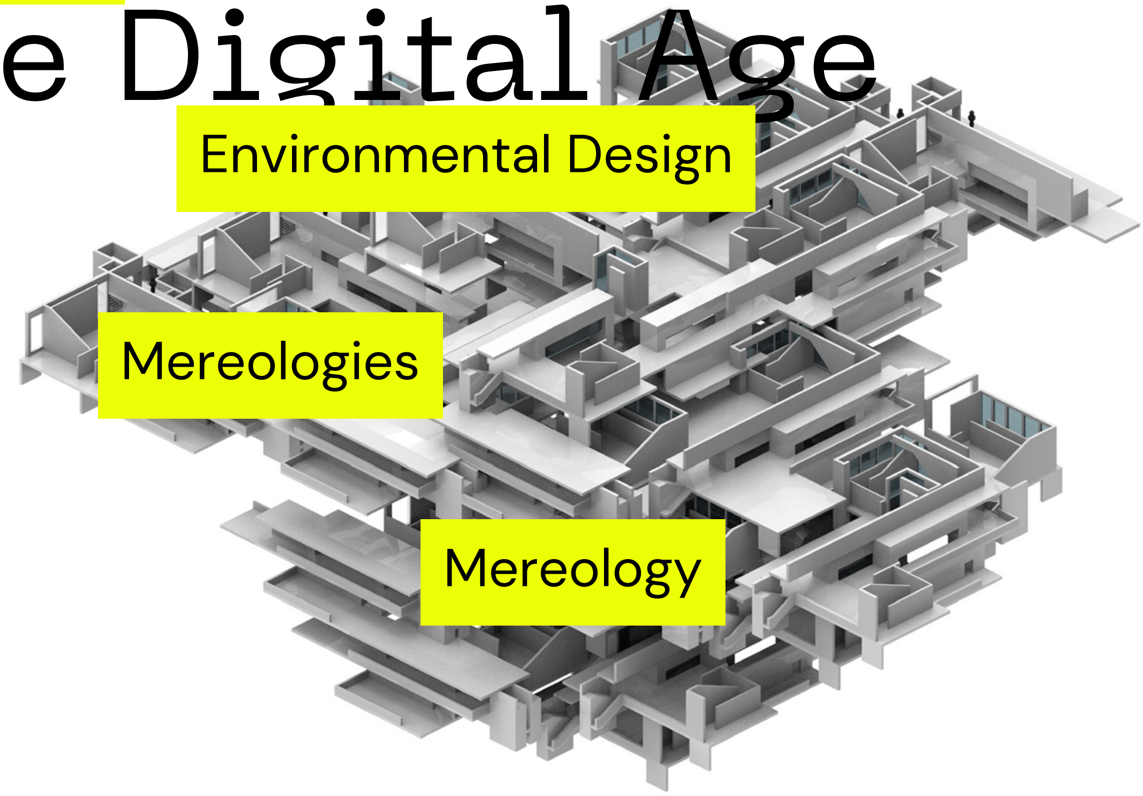
I do not use the same grammar for every building. I could, but I want to try different things. There are many people who thought housing should be produced in a factory, like cars. It is such a simple idea. But it doesn't work, because every location has its own needs, whereas a car is the same everywhere. So, you can not use the same grammar. I use another grammar for a school and another for housing for instance. Some things have a similar grammar, like how you make a door, which works in most cases.

Do you have a particular vocabulary of elements that reappear during your career in different articulations and styles?

Architecture should accommodate people and things that people are concerned with. I use this everywhere. To give you a simple example: when I make a column, most of the time I design it with a base for people to be able sit on it. This is for me an accommodating device. It always works. This sort of thing is universal in my opinion: the idea of accommodation. Another example is the handrail of a stair. I always make a handrail that guides you where to go, making the end of it in such a way that even without looking you have the feeling that this is the end of the stairs. Everything I do tries to consider how it works for people. However the point is that it should be friendly to people, but not soft.

Friendly architecture! This is a wonderful conclusion. Thank you, Herman Hertzberger for sharing your time and thoughts with us.

Article 9 : When Architecture Thinks! Architectural Compositions as a Mode of Thinking in the Digital Age



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“One must turn the task of thinking into a mode of education in how to think.”[1]

These words from the philosopher Martin Heidegger point towards new modes of thinking. As architects, one can mention Mario Carpo’s remark about the huge amounts of data that are available for everyone nowadays: most of it is underused.[2] As this essay will argue, this new condition of Big Data, and the digital tools used to comprehend and utilise it, can trigger an entirely new way of thinking about architecture. It is a way to both open doors for testing, and an opportunity to look back into history and re-evaluate certain moments in new ways. As an example one can take Brutalism, which emerged as a post-war period solution in the 1950s. It was a new mode of thinking about architecture that was influenced by Le Corbusier’s Unité d’Habitation de Grandeur Conforme, Marseilles (1948–54), the Industrial Revolution and the age of the mechanical machine. Brutalism can be read as the representation of reading the building as a machine at that time. Luciana Parisi has expanded on this idea, writing that Brutalism can be considered as the start of thinking about architecture as a digital machine, having removed any notion of emotion from the architectural product, leaving a rough mass of materials and inhabitable structures.[3] In Parisi’s sense, brutal architecture can then be read as a discrete system of autonomous architectural parts brought together with a set of rules: symmetry, asymmetry, scales, proportions, harmony, etc. These rules, materials and structures act autonomously using collective behaviours to produce data. The data can then be translated into concrete compositional elements which form a building, a city or a whole territory. The adjacencies between each discrete compositional element creates the relations between those parts.

Figure 1 – Thinking parts interacting to produce a building. Image: Espen Dietrichson, Hard Edges, Cloudy Cities, Galleri Haaken, 2018.

The Building Thinking Machine

The building as a machine departs from Le Corbusier's claim for a functional architecture.[4] Today, the use of machine learning and artificial intelligence means that machines are no longer used only for making. They are thinking machines.[5] This allows a new translation of Le

Corbusier's understanding of function, asking the questions: what if architecture acts as a mode of thinking? How would a building as a thinking machine perform?

The generation following Le Corbusier progressed the building machine. Regner Banham linked the building machine to comfort and the environment,[6] seeing the building as a kit of tools that provide comfort. In other studies, Reyner Banham proposed the building as a package which is totally enclosed and isolated from the external environment, referring to this as "the environmental bubble". He proposed that surrounding the building with one thick layer that protected the internal space was the best solution to provide a well-tempered environment. Yet Banham presents a clear separation between the interior and exterior spaces which no longer matches the complexity of interior-exterior relationships at both urban and architectural scales.

Mereological Reading of Architectural Precedents

Different types of systems that provide for a well-tempered environment inside the building distinguish difference between inside and outside as the difference between a well- and non-tempered environment. Mereology, or the study of parts-relations,[7] can be used as a methodology to read a building in terms of its compositional aspects.

One historical example is the Rasoulian House (1904) which was designed to provide a state of comfort for its users throughout the year. A basic architectural element known as the wind catcher tower, or Malqaf, provided the building with breeze. As Sarinaz Suleiman described, the Malqaf is a composition of architectural elements that work together to create air flow. These elements include walls, doors, rooms and include the basement and the courtyard, organised in a specific order, proportions and orientation to create specific relationships between the inside and the outside.[8]

The Malgaf is the first point at which air flow enters the building. It then travels down a shaft which is the first interior space that the wind interacts with. The air continues to a second interior space through a window-like opening into a room, and then is moved through an opening in the room's floor to a cellar space under the building. This third interior space is the coolest space in the building. The cellar is connected to the courtyard through an opening that facilitates air circulation and absorbs wind. For this to happen, two kinds of relationships need to exist: the exterior relation formed by the geometry of two elements, e.g. the height of the Malqaf and the width of the courtyard which help to create a high difference in air pressure, and an internal relation which is controlled by the openings between the interior spaces and between interior and exterior spaces as well. Ventilation is not only a void space, but another level of interiority inside the building.

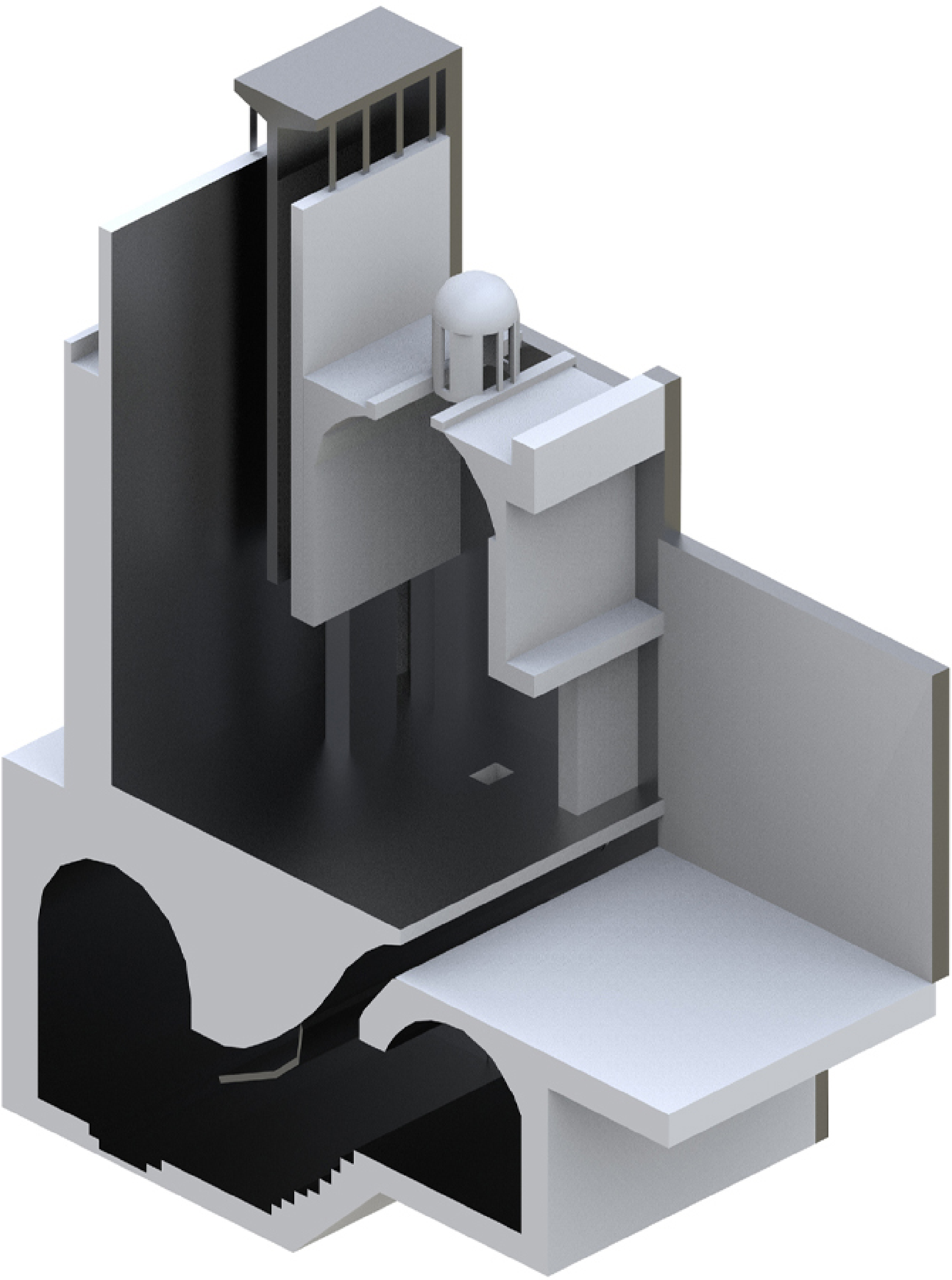


Figure 2 – An architectural precedent for ventilation, Rasolian house in Yazd city, Iran, 19th century. Image: Sheghaf Abo Saleh, 2020.

Another example of a complex ventilation system is a data centre building.[9] Data centres usually produce vast thermal exhaust which requires constant air movement, requiring large depths to ceilings and floors which may be as big as the building itself. Servers are positioned in the room with a certain distance between each other. This distance is related to the degree of temperature and the air circulation speed. Higher temperatures inside the room are used to decrease air pressure and create a pressure difference that enables air circulation naturally in the room. The path that the air travels allows the air the time it needs to cool down naturally.

Computational Ventilation

Hundreds of years ago, Vitruvius described wind, saying that "wind is a flowing wave of air with an excess of irregular movements. It is produced when heat collides with moisture, and the shock of the crash expels its force in a gust of air."[10] Vitruvius' definition can be deconstructed into two parts, the first of which deals with the dominant wind direction and its relation to the outer envelope of the building. This concept was emphasised by Vitruvius' example of the Octagon Marble Tower (15th century BC). The second part relates to the process of creating wind flow in nature. Vitruvius explains that air circulation occurs when two different air pressures encounter each other. The difference in the air pressure always happens as a result of changes in temperature and moisture. High temperature heats up the air causing low density and consequently low pressure areas, and lower temperature will create a high pressure area. This concept is the logic that has been followed in all passive ventilation systems throughout history. These systems tend to create two points with a high difference in pressure, connecting these two points with a path that needs to be ventilated. This path would then move through the building accelerating air movement from the high pressure area to the low pressure area creating air flow inside the building.

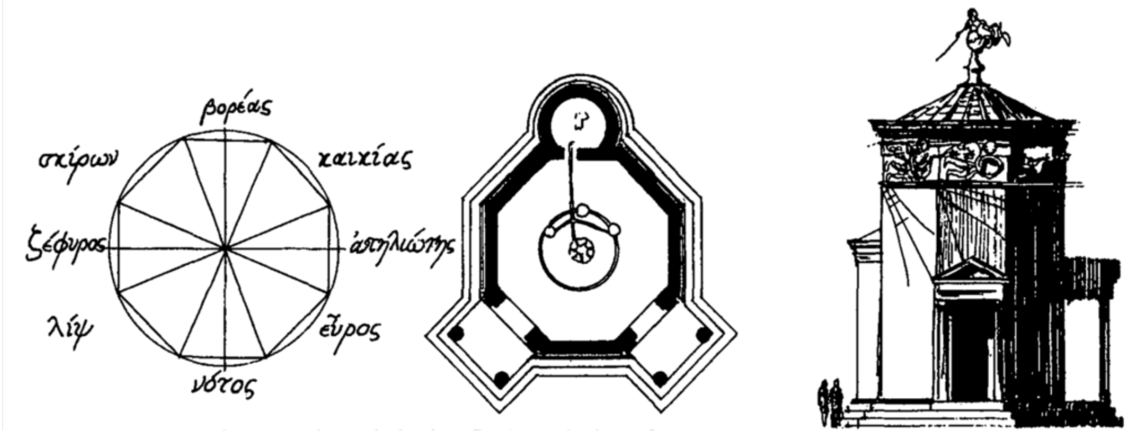


Figure 3 – The Octagon Marble Tower, Athens, Greece. Image: Included in Vitruvius' *Ten Books on Architecture*, 15th century BC.

A traditional building from the Middle East can be taken as a case study for applying thermodynamic logic to create natural air circulation in a building. In the previous example of Rasolian House, the side that is exposed to the sun is heated up by the sun. Consequently, air pressure decreases. The geometry that is exposed to the sun creates shadowed areas inside and outside of the building. These shadowed areas are much colder and have high air pressure. Air circulates from the high pressure to low pressure areas. That means air can move from a cooler courtyard to an upper space located above it. This air movement absorbs the air from inside the building to fill in the void in the courtyard that the high pressure air had left behind when it moves upwards. Due to the opening at the top of the shaft, air will enter the building to fill in the void that the inner air has left behind as well. This air replacement creates the air circulation inside the building. The creation of wind is dependent on the design of the inner space and its relation to the outer space through openings. This means that, by closing and allowing openings, wind can be created or stopped, and by changing some openings, the wind flow path can be changed, and wind speed could increase or decrease. This follows a logic of discrete, combinatorial air flow.

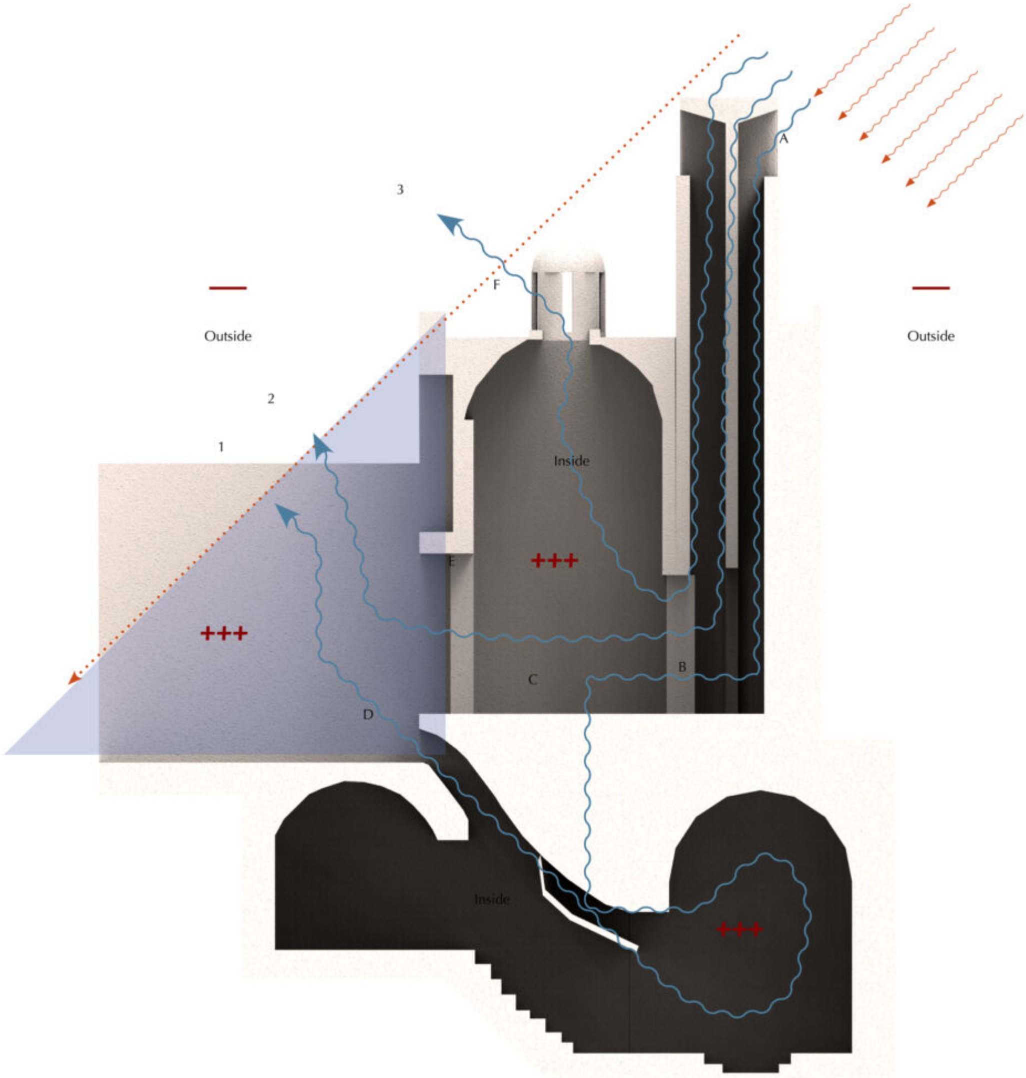


Figure 4 – Section in a wind catcher shows the path of the wind as a binary system controlled by switching circuits. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

Computation Ventilation on the Urban and Architectural Scale

The building can be seen as a machine for creating an environmental condition through compositional thinking. This way of thinking turns the building, in the case of the Malgarf, into a switch that can turn the air flow on and off. In this instance, the creation of wind is entirely dependent on a series of elements that are well- organised and ordered. From this combinatorial thinking, wind can be read as a form of pre-digital computation considering the inside-outside sequences as what causes the air flow.

The order of inside-outside also plays an important role in disrupting air flow. A single element that has been extracted from a building can serve as an example. It is a corridor, but at the same time this element plays a crucial role in creating wind. The way that the walls are arranged produces a contrast between the inside-outside spaces. Moreover, the design and arrangement of the openings turns the corridor into a path for air. Taking this element as a discrete part, and rearranging its parts within the same local rules that have been set over the ventilation logic, another version of the element emerges. Following this same logic would give different versions of different elements. Further on, each version of each element has its discreteness and can be upscaled. With this upscaling strategy, more complex interiors emerge.

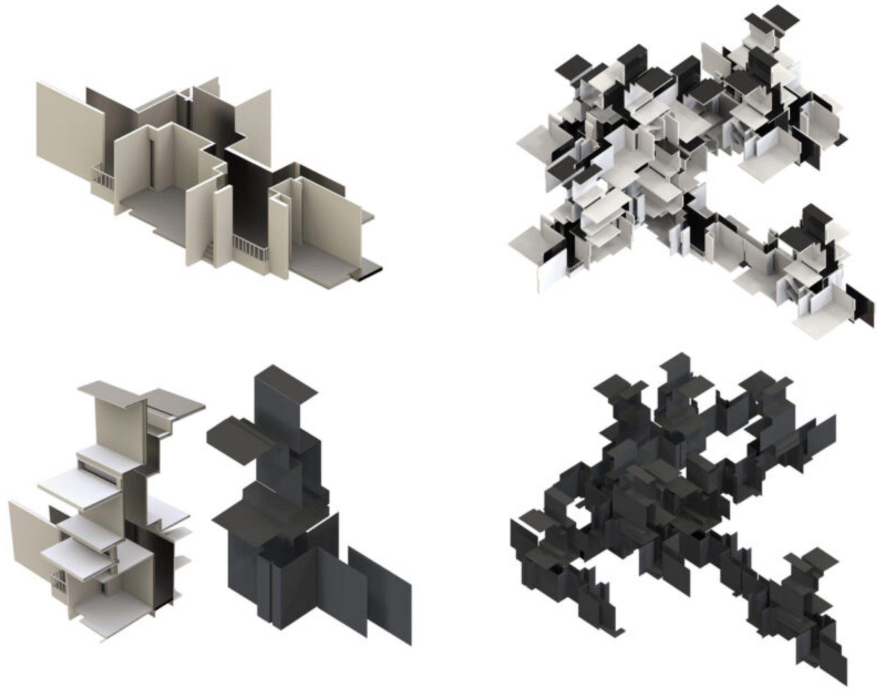


Figure 5 – (clockwise, from upper left) Extracted element from a church in Finland; new version of the element with mereological changes; arrangement of ten elements combined in a way that ensures the wind flow runs through the whole system; the path that wind flow draws. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

By integrating an environmental aspect within the design process, a new type of building that embraces another wind geometry can be created. This provides an opportunity to design highly dense architectural forms that can reassure the qualities of the internal space. By nesting interiors one can create different low and high pressure areas over inside-outside sequences.

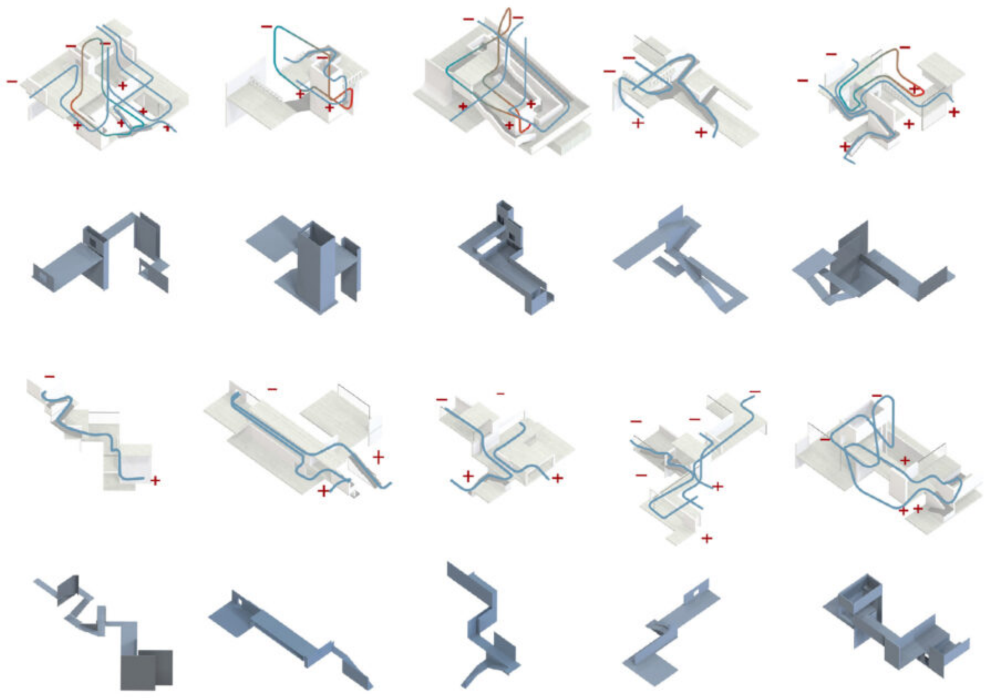


Figure 6 – Different arrangements of [-][+] situations and what they create as wind patterns, the discreteness of the wind flow, wind-geometry. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

This allows a rethinking of the inside-outside arrangement in the city according to what positive or negative sequences are created. For example, for more similar interiors less contrast in air pressure needs to be produced. For more variation between the interiors, the contrast in the air pressure needs to increase and more air will flow. An air circulation concept can be used as a means to arrange both interior and exterior spaces in the building and in the city.

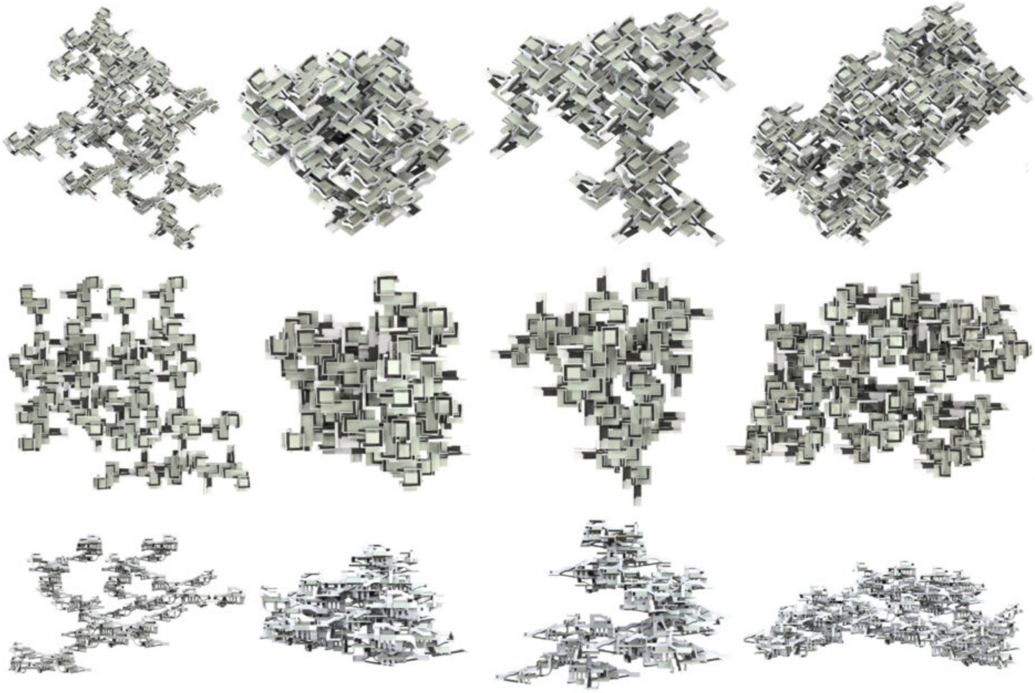


Figure 7 – A range of building fragments with the same number of elements but different [-][+] sequences, by more to less wind flow. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

Achieving Banham's Campfire

At an architectural scale the interior-exterior relation can also be managed by the building façade. The façade tends to be used to provide separation between indoor and outdoor spaces as well as between a tempered and non-tempered environment in order to achieve comfort. However, a new understanding of wind circulation can provide a well-tempered environment regardless of the façade. In other words, façade here can be seen as the tools or the elements that provide comfort and facilitate air circulation inside the building.

A façade needs to meet specific criteria in order to generate a difference in air pressure just like the inside-outside arrangement in the city scale. Three design parameters can support this: the orientation of the elevation in relation to the sun, the number of layers that are needed to create more or less tempered areas and the degree of translucency of the façade that helps to prevent or allow sunlight which helps in its turn to reach the preferred temperature. The facade is not any more the envelope of the building, it is the layers that are responsible for providing the comfort inside the building.

Figure 8 – Building fragments. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

Indeed, thinking about architecture through architecture's interiors can expose low-tech computation that starts from a thermodynamic discreteness. This enables the understanding of spatial sequence that can support different levels of space in a building and the notion of layers of building-in-buildings. If this concept is upscaled to the scale of the city it could be an opportunity to study the kinds of patterns that mereology can create utilising environmental thinking. This means that a building, or even a city, could become an example of the campfire that Banham aimed to reach many years ago.[11]

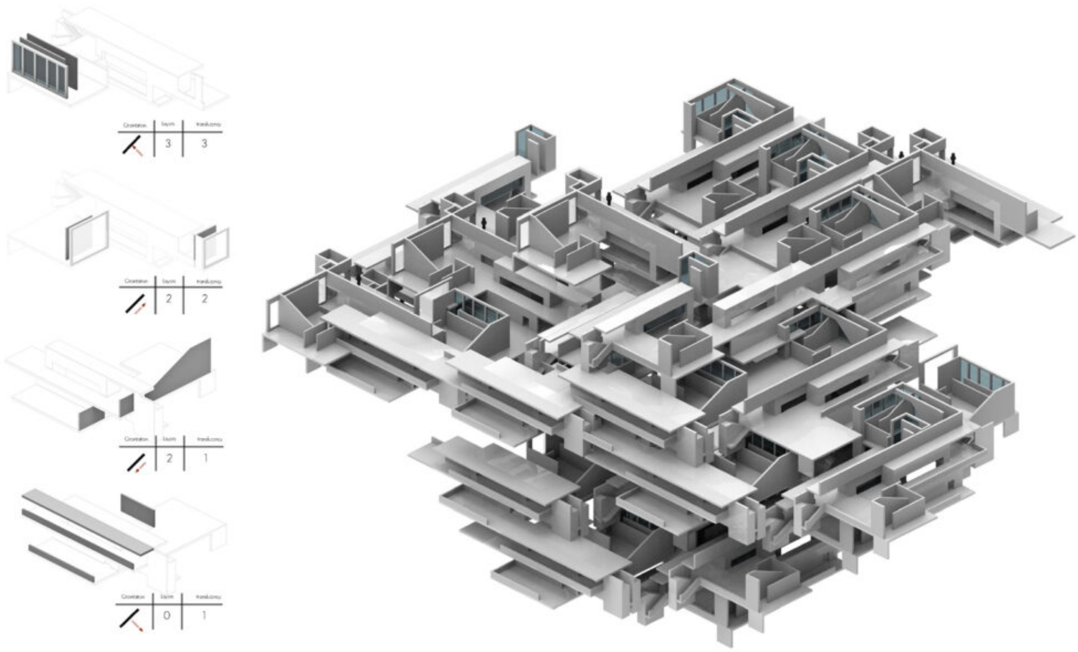


Figure 10 – Building fragment implemented with the façade concept. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

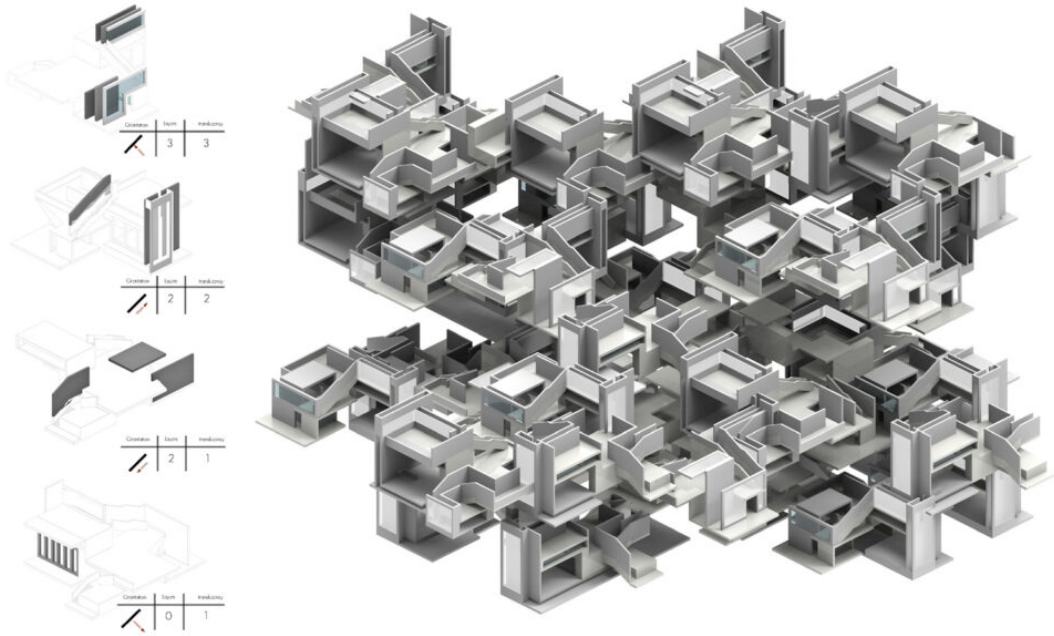


Figure 11 – Building fragment implemented with the façade concept. Image: Sheghaf Abo Saleh, RC17, The Bartlett School of Architecture, UCL, 2018.

Article 10 : The Ultimate Parts: A Mereological Approach of Form Under the Notion of Object-Oriented Ontology

Architecture

Architecture Theory

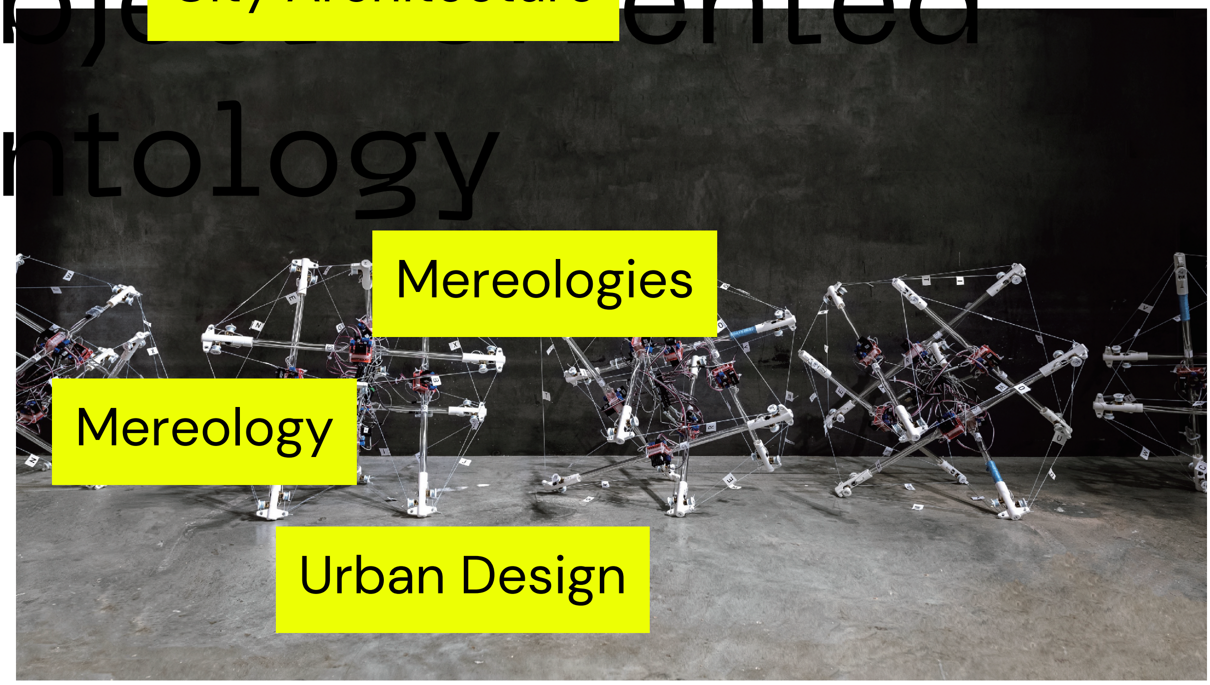
City Architecture

Form

Mereologies

Mereology

Urban Design



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Mereology is a formal concept which enters architecture as an additional formal category. Form is a rather ambiguous concept in architecture. So in this essay, first an investigation is conducted by contrasting two closely related concepts: shape and content.

Hans Trusack criticises the problem of shape for its shallow formalism and historical-theoretical indifference as a defensive strategy that evades the disciplines and difficulties of past and future.[1] The distinction between the terms “form” and “shape”, following Tursack’s argument, is a “matter of generative process”. Both terms point to the production of visual expression. Yet while shape refers to the appearance of an object, form reflects the logic of transformation and operation within historical and theoretical contexts such as political and religious ideology, economics and technological background. Tursack criticised the strategy of shape in architecture, stating its lack of reference, it being “plainly, and painfully, evident”,[2] and incapable of moving forward. Whereas form is difficult, disciplinary and requires historical and theoretical study, and yet promises the future.

Form has the advantage of being able to deal with complex relations due to its deep and continuously evolving intervention with content. The term form derives from the Latin word *forma*, is understood as the combination of two Greek words: *eidos*, the conceptual form, and *morphe* , the physical form. The complexity of form can be attributed to these differentiated meanings, yet complexity is compatible with agencies and relations. This can emerge further by conducting a brief historical review.

Ancient Greek architecture pursues the ideality in mathematics and proportion. The efforts made by architects in designing the Parthenon provides evidence of this feature. These operations tried to approximate the physical shape of architecture to the “ideal” form. Form reflects the pursuit of ideality and perfection in this period.

For Gothic architecture, there were more concerns about structure, and matter was pushed to its maximum capability to build as tall as possible for religious appeal. Consequently, structures were designed to be rigid and lightweight, and solid walls were replaced by glass windows, while flying buttresses supported the main structure to grow even taller. Consequently, astonishing space and fascinating transparency emerged.

Modernism claims that “form follows function”,[3] rejecting traditional architecture styles. The reality of matter and the logic of technology eschewed decorations, proportions, or any subjective distortion of matter. The emphasis on the term “function” illustrates an ideology of treating architecture as a machine. Each part is nothing more than a component that has a certain feature inside this machine, and redundant decorations and details are removed to deliver this idea clearly. Without distractions, space becomes evident.

In the shift to postmodernism, the uniformity and the lack of variety of modernist architectures were reacted against, and a great variety of approaches emerged to overcome the shortcomings of modernism. Parametricism, for instance, has been promoted by the thriving of digital technologies. Designers are capable of more complex formal production, and architectural elements have become variables that can be interdependently manipulated. In this formalism, rigidity, isolation, and separation are opposed, while softness, malleability, differentiation and continuity are praised.

From the examples above, form is the embodiment of the relations between architecture and its motive in specific historical scenarios, while for shape, only the results are accounted for – relations are ignored, and architecture is treated as isolated physical entities, incapable of producing new relations. Different methodologies of dealing with architectural form also imply the variation of ideology in compiling form with content.

Mereology — An Approach of Architectural Form

In recent philosophical texts, a third notion of form is brought forward. Contrary to a dialectic of form and content, here investigations deal with the resonance of parts: the description of objects by their ontological entanglement only. The writings of the philosopher Tristan Garcia are a strong example for such mereological considerations. In his treatise *Form and Object: A Treatise on Things* (2014), Garcia investigates the ontology of objects with two initial questions, "… what is everything compose of? … what do all things compose?"[4] The first question interrogates the internal, the elementary component of everything. The second interrogates the external, the totality of everything. For Garcia, the form of a thing is "the absence of the thing, its opposite, its very condition,"[5] form has two senses, the "beginning", and the "end", which never ends. Form begins when a thing ends, it begins with different forms; in the end, since it has "endless end", form ultimately merges into one, which is "the world". Garcia defines an object as "a thing limited by other things and conditioned by one or several things."[6] The form of an object depends on what comprehends or limits this object. Every object is "embedded in a membership relation with one or several things",[7] they can be divided by defining limits, which is also a thing distinguishing one thing from another. Garcia's argument adapts the concept of mereology. Form has two extremes, one toward the fundamental element of matter, and the other toward the world, comprehending everything. All things can always be divided into an infinite number of parts, and they can always be parts of another thing. Identifying parts or wholes within a section we can operate on can establish a limit. The relevance between form and mereology opens a new opportunity to inspect architectural form from a different point of view.

One of the first discussions about parts and wholes in modern philosophy was posed by Edmund Husserl, in *Logical Investigation* (1st ed. 1900-1901, 2nd ed, 1913),[8] but the term "mereology" has not been put forward until Stanisław Leśniewski used it in 1927 from the Greek work *méros* (parts).[9] Mereology is considered as an alternative to set theory. A crucial distinction lies between mereology and set theory in that set theory concerns the relations between a class and its elements, while mereology describes the relations between entities. The mathematical axioms of mereology will be used as the fundamental theory of developing the method of analysing architectural form.

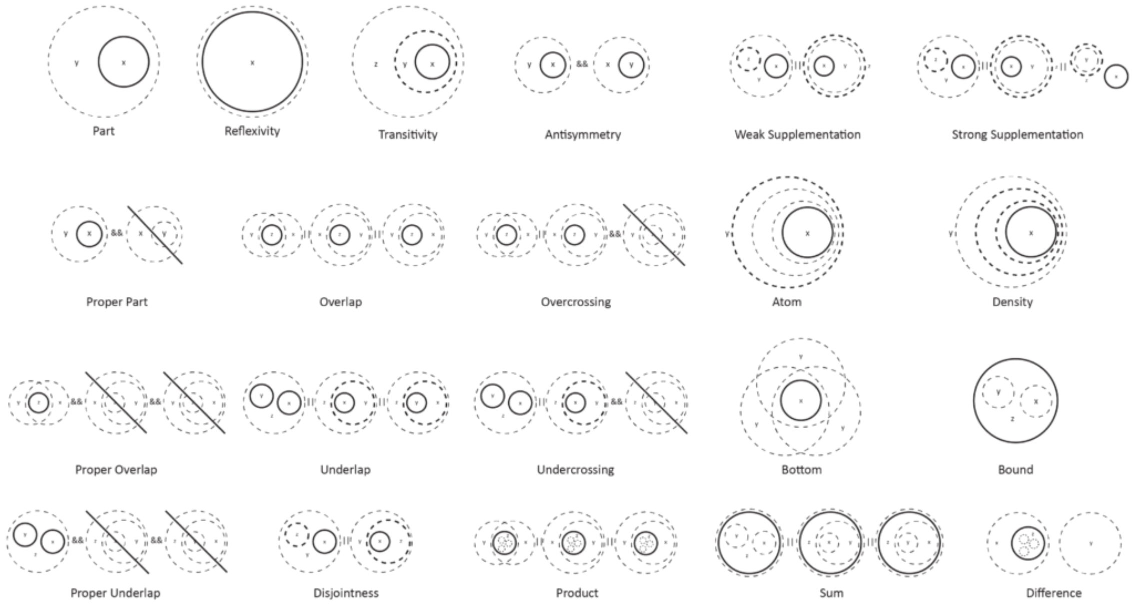


Figure 1 – Diagrams for Mereological Relation in Mathematics, Ziming He, 2019. Image credit: Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2019.

Following Roberto Casati and Achim Varzi, the four fundamental mathematical formularisations of mereology are: "Relations are reflexive, antisymmetric and transitive. (…) First, everything is part of itself. Second, two different objects cannot be part of each other. Third, each part of a part of a whole is also part of that whole. Fourth, an object can be a part of another object, if both exist."[10]

Mereology can be a promising approach also for the reading of architectural form, as it emphasises relationships without reducing buildings to their appearance or function. However, such philosophical descriptions consider wholes and parts as mostly abstract figures. Therefore, a supplement could be developed to properly categorise the mereological relations in the field of architecture. Having the relations between form and mereology addressed, methodologies can be developed to access the analysis of architectural form. Mereology as a specific methodology for architecture is quite new. One of the first introductions can be found in Daniel Koehler's book *The Mereological City: A Reading of the Works of Ludwig Hilberseimer* (2016). Here, Koehler departs from the modern city, exemplified through the work of Ludwig Hilberseimer to illustrate mereological relations in the modernist city. From the room to the house to the city to the region, Hilberseimer canonically drew the city as a hierarchical, nested stack of cellular spaces.[11] However, through the close reading of its mereological relations it becomes clear that political, economic or social conditions are entangled in a circular composition between the parts of the city. Recalling Garcia's discourse, and resonating with Leon Battista Alberti's thesis, Koehler shows that the cells in Hilberseimer's modernist city are interlocked. A house becomes the whole for rooms; a city becomes the whole for houses. By considering the city and its individual buildings equally, "the whole is a part for the part as a whole."[12]

Architectural Relations Between Parts and Wholes

Parts are not only grouped, packed and nested through different scales, but also in different relations. Specific relationships have been developed in different architectural epochs and styles. Mathematically, four general classes of relations can be drawn: whole-to-whole, part-to-part, whole-to-parts and parts-to-whole, while more specific subclasses can be discovered from each.

According to the mathematical definition, between wholes there exist complex relations, the whole could exist on any mereological level, and the complexity of relations between multiple levels are also accounted for. Whole-to-whole relations can become complex when considering multi-layer interaction, and more relations can be identified: juxtapose, overlap, contain, undercrossing, transitivity, partition, trans-boundary, intact juxtapose, compromised juxtapose.

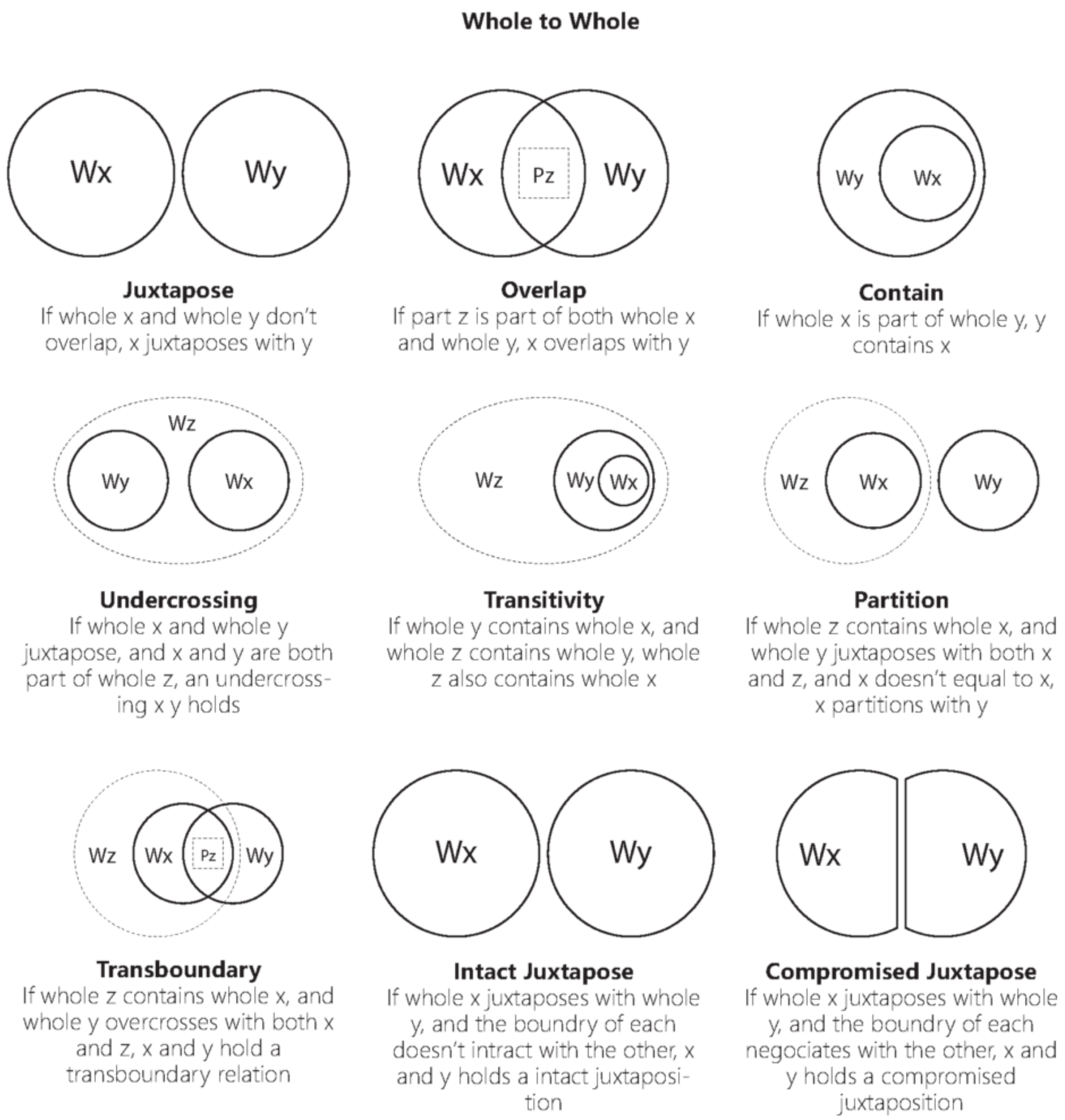


Figure 2 – Whole-to-whole relations. Image credit: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

A first glance of New York, gives the impression that it is quite heterogeneous, but underneath there is a city grid underlying the heterogeneity, and while the relations displayed in the grid are rather simple, all wholes juxtapose with one another. In comparison, in Siena, an Italian city, the urban space is quite complex, where boundaries of all wholes negotiate with others, the gaps in between are carefully treated, the nesting relations are extremely rich, and multiple relations from the diagram above can be found.

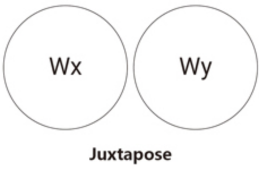


Figure 3 – New York. Image: Jonathan Riley.

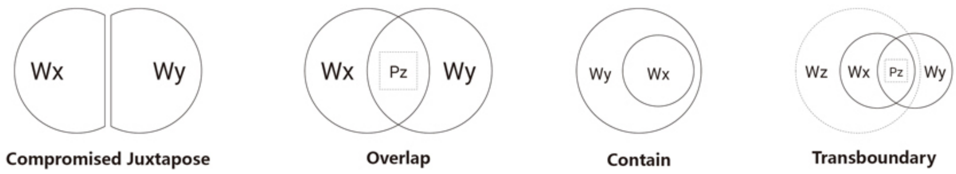


Figure 4 – Siena. Image: Cristina Gottardi.

The whole-to-parts relation studies what the whole does to its part, namely in terms of top-down rules. The mathematical definition does not involve specific situations that a whole-part condition holds. Distinctions within individual contexts make a significant difference in clarifying an explicit relation. The situations for the whole can generally be classified into following types: fuse, fit and combine.

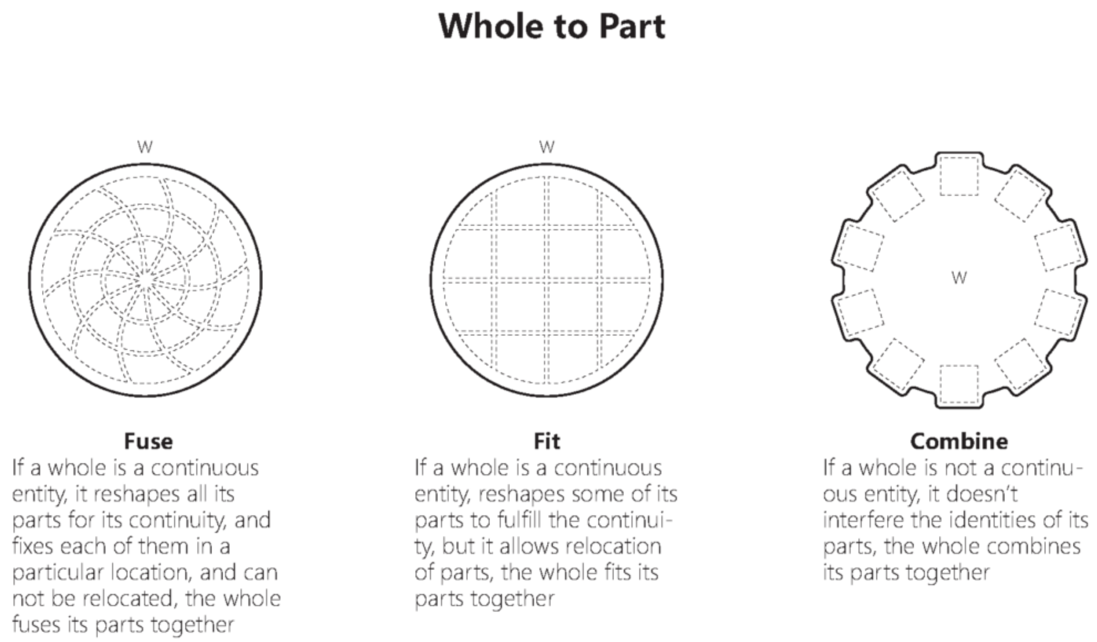


Figure 5 – Whole-to-part relations. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

One of Zaha Hadid's projects, Heydar Aliyev Centre, indicates the fusing relation. Architecture is represented as a smooth, fluid volume. The distinction between elements disappears, and this dominating power even extends to the external landscape. In order to maintain a continuous whole, parts are fabricated into a particular shape, having their unique unchangeable locations. The continuous whole excessively overwhelms the parts, yet not all parts are reshaped to fuse into the whole, and because the parts are small enough in relationship to the whole, the control from the whole is weakened, and parts are fit into the whole.

The third type is combining. An example for this relation is Palladio's project Villa Rotonda. In this case, parts are obvious. The whole is a composition of the parts' identities. However, the whole also holds a strong framework, in a rigorous geometric rule that decides positions and characters of parts. The arrangement of parts is the embodiment of this framework.

Figure 5 – Heydar Aliyev Centre, designed by Zaha Hadid Architects. Image: Orxan Musayev.

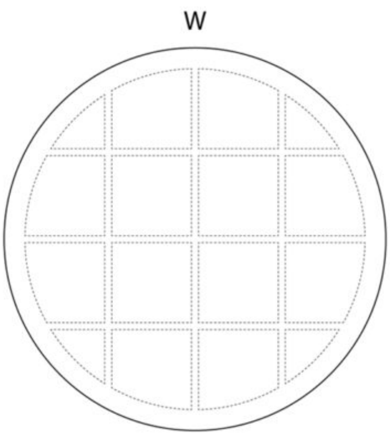
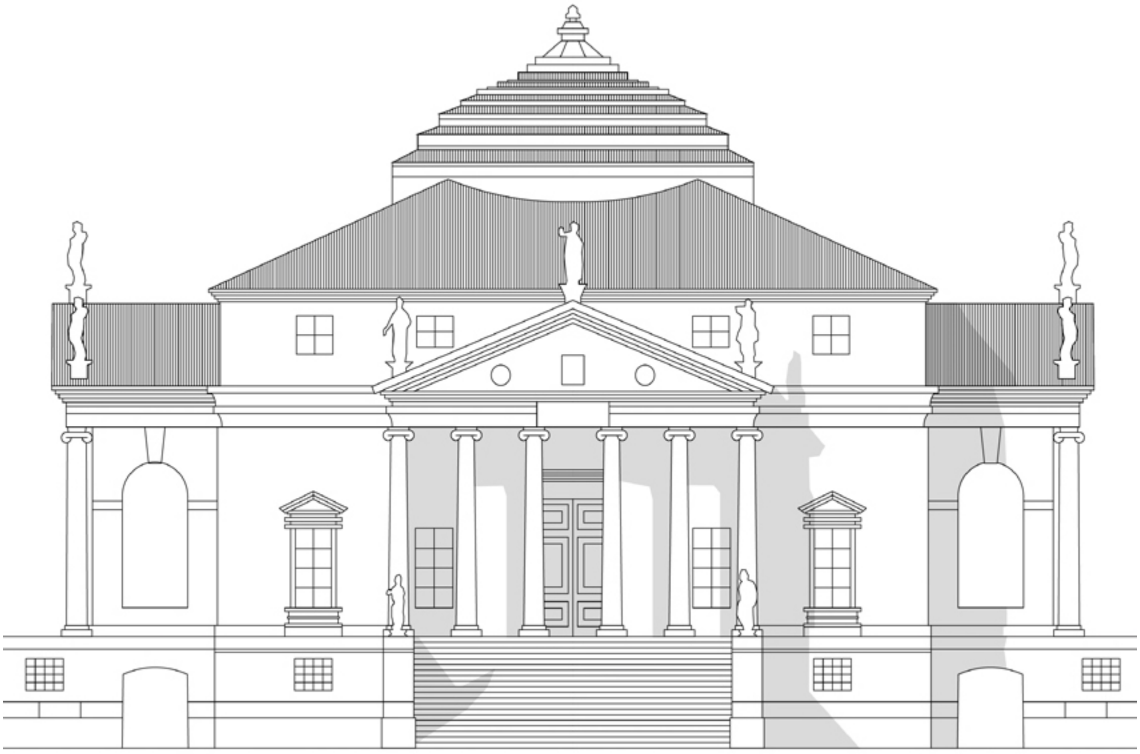
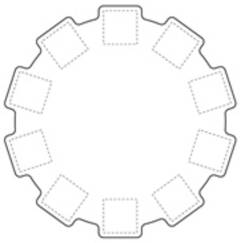


Figure 6 – Diagram of fitting relation. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.





Combine

Figure 7 – Façade of Villa Rotonda. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

The parts-to-whole relation studies what the parts do to the whole, or the power of bottom-up relationships. The different situations of parts are also key parameters in validating a given relation. The classification of situations for parts are as follows: frame, intrinsic frame, extrinsic frame, bounded alliance, unbounded alliance.

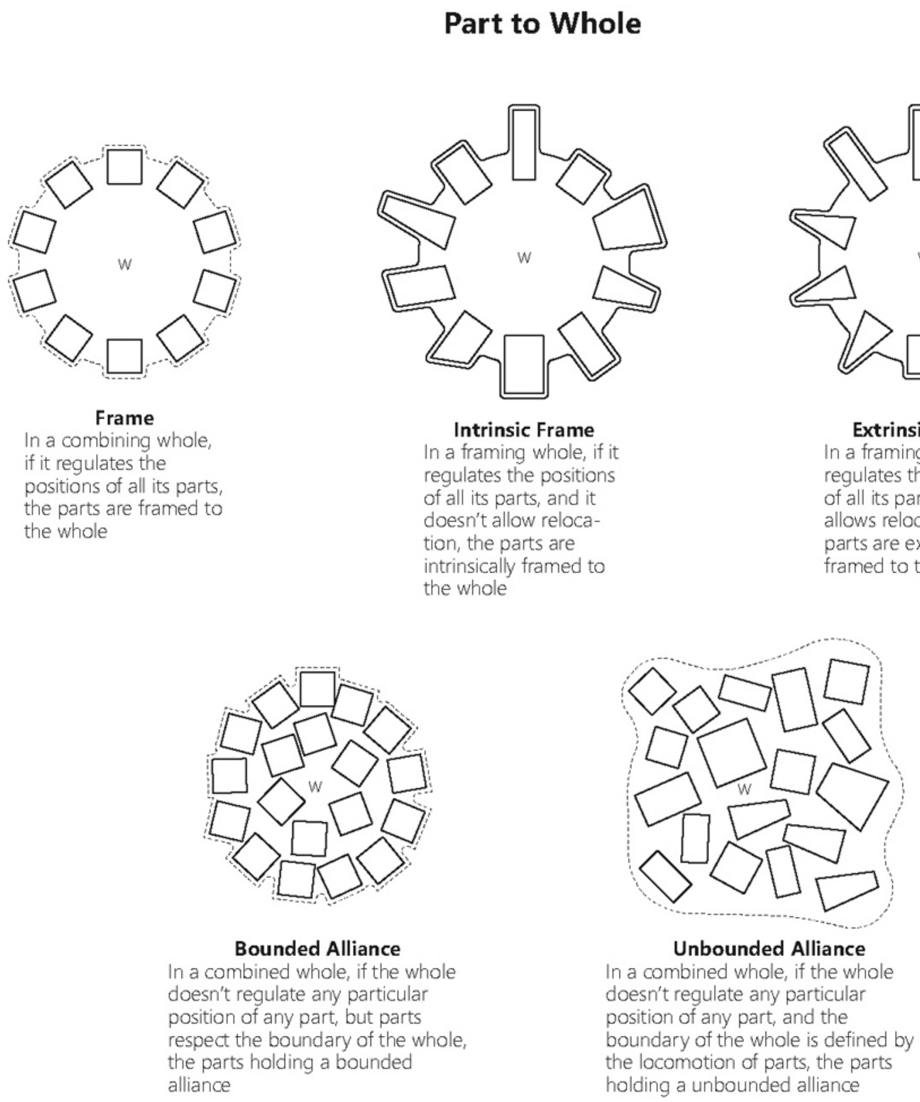


Figure 8 – Part-to-whole relations. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

Emil Kaufmann thoroughly investigated the innovative works by Claude Nicholas Ledoux in *Three Revolutionary Architects: Boullee, Ledoux and Lequeu* (1952).[13] According to Kaufmann's study, Ledoux's works developed new compositional relations of elements from the Baroque. The characteristics of parts in Baroque architecture are rich, but tend to regulate the identities of all the elementary parts and fuse them together to serve the harmony of the whole, presenting the intrinsic framing. Ledoux's work is an extrinsic framing, where the parts are relatively independent, with each element maintaining its own properties, and while consisting of the whole, they can be replaced with other identical components.

One of my projects in discrete aggregation of elements presents an unbounded alliance relation. The aggregation as a whole shows a form that is discretised (Figure 12), and does not pass any top-down instructions to its parts.

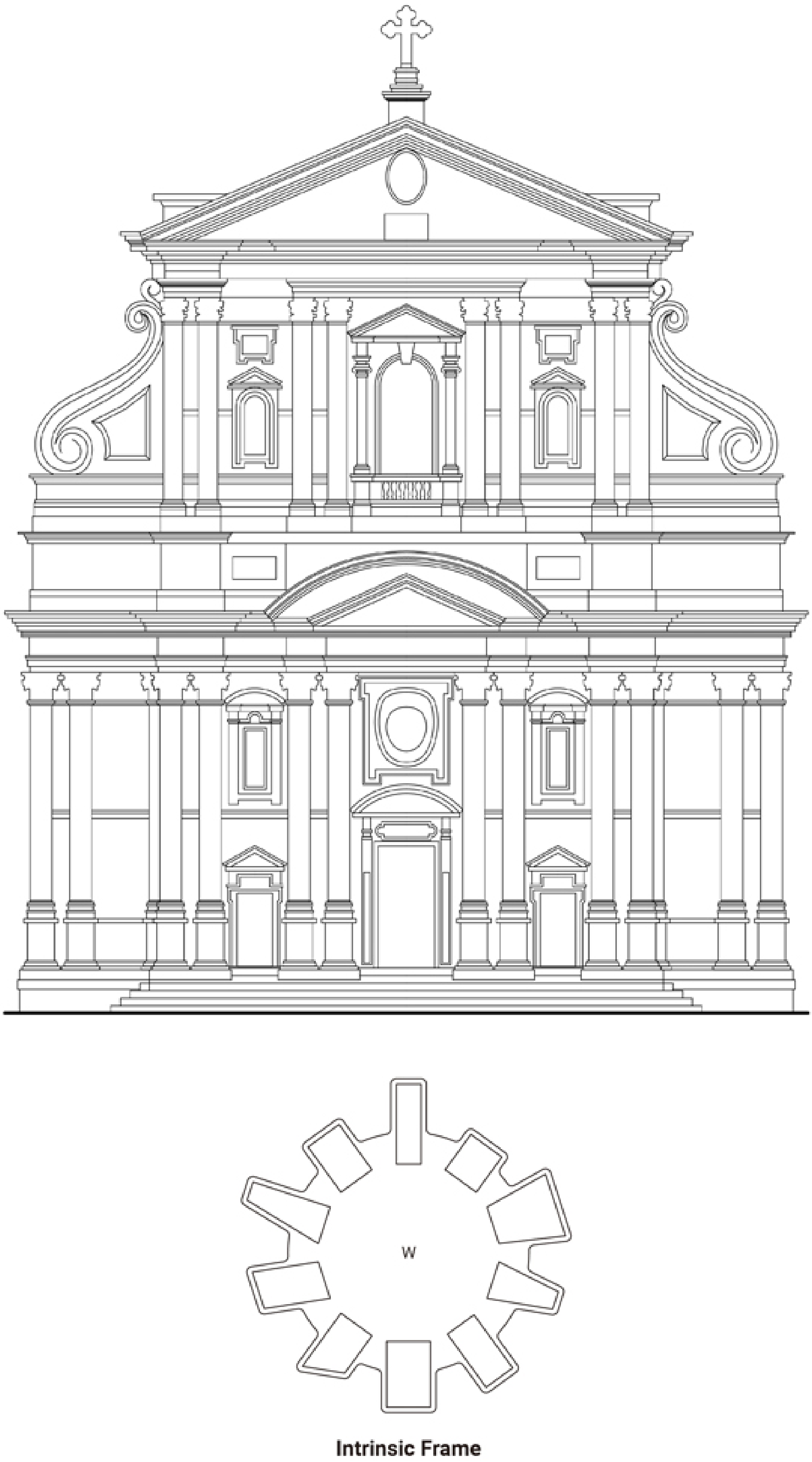


Figure 9 – Facade of Church of the Gesù. Image: Ziming He, Living

Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

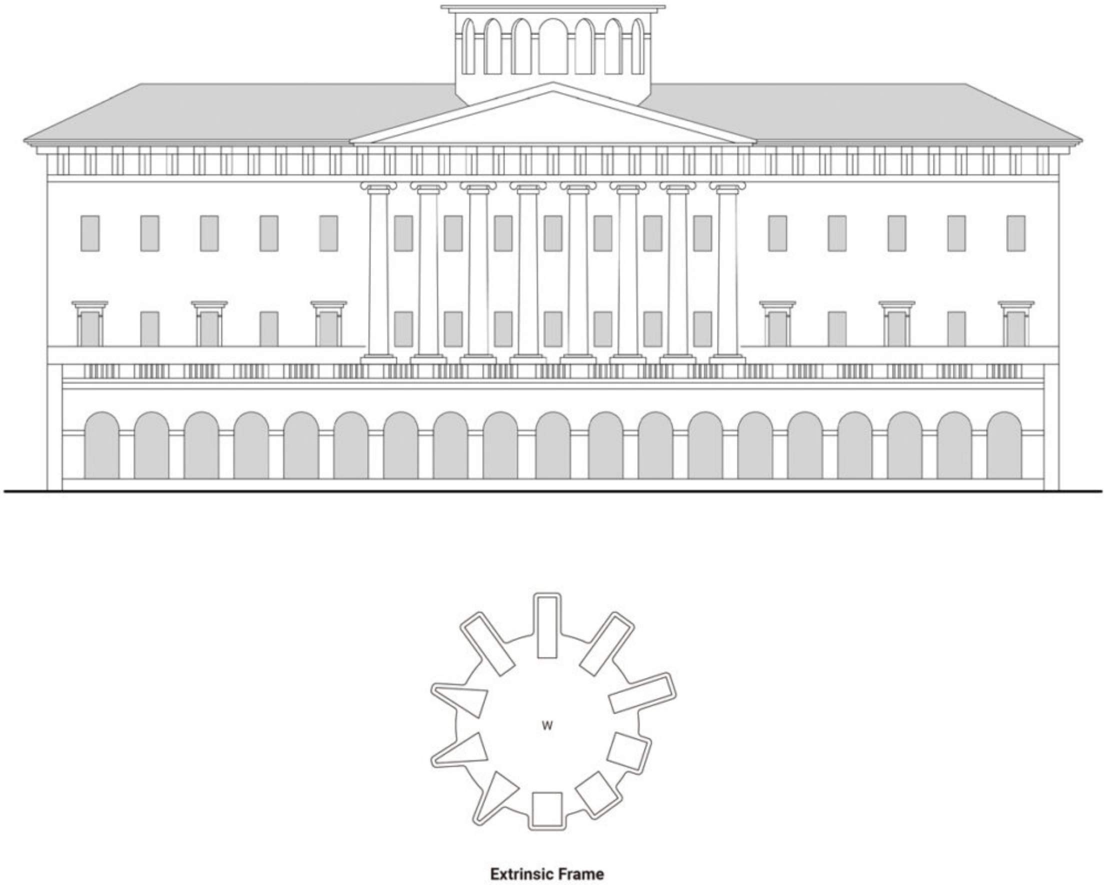
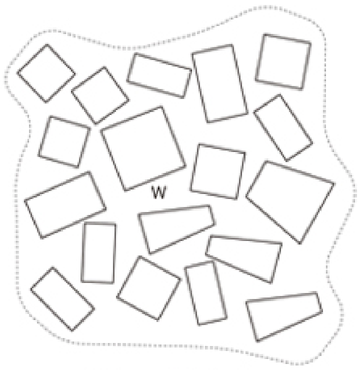


Figure 10 – Façade of Château de Mauperthuis. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.



Unbounded Alliance

Figure 11 – Discrete aggregation. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

Part-to-Part Without Whole — The Ultimate Parts

For part-to-part relations, local interactions are emphasised, and interactions occur at multiple levels of compositions, where the part-to-part relations in some cases are similar to that between wholes. It has following classifications: juxtapose, interrelate, contain, partition, overlap, trans-juxtapose, over-juxtapose, over-partition, over-overlap.

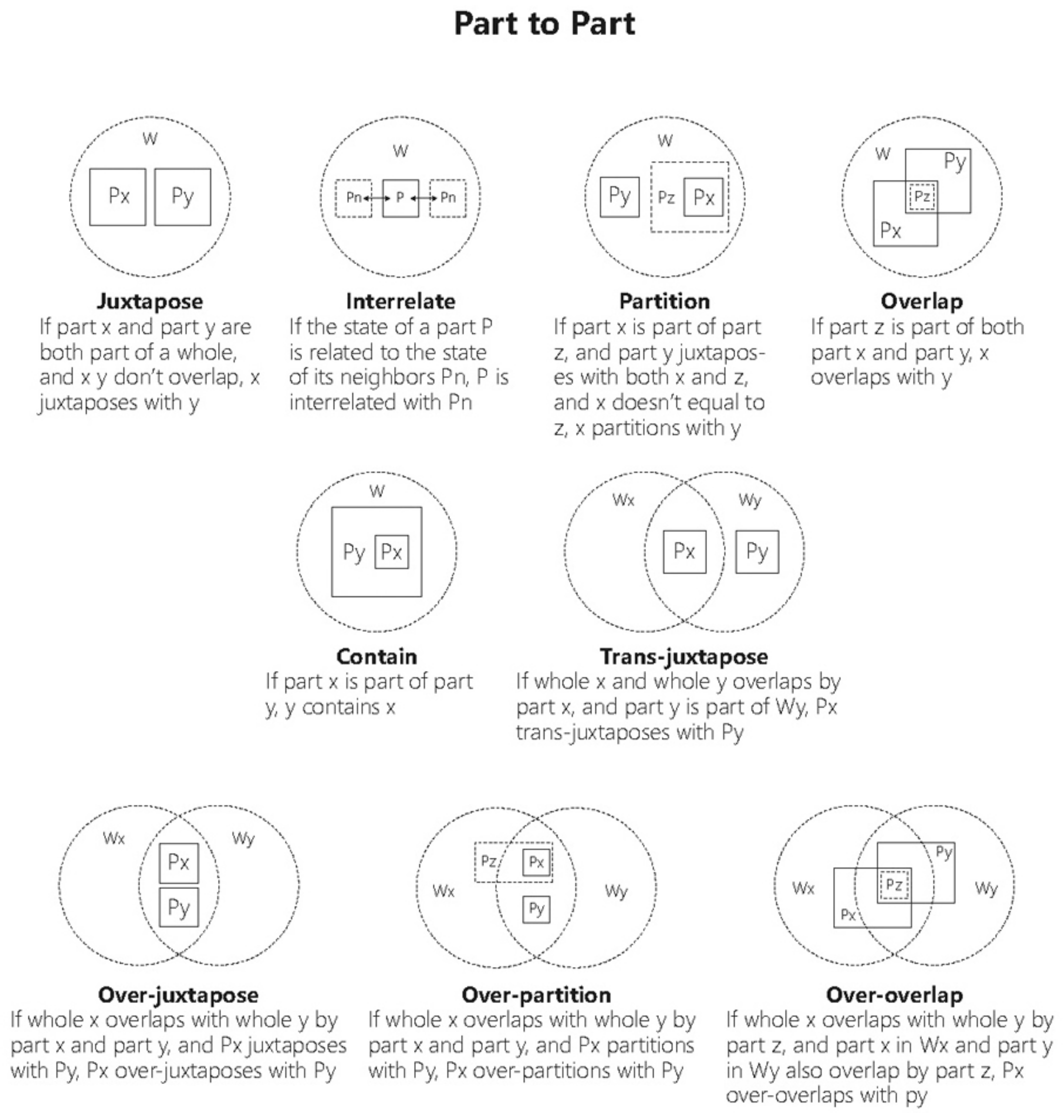


Figure 12 – Part-to-part relation. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

Architects have been working on the possibility of removing the whole by studying the part-to-part relations. Several approaches have been developed, mainly through computation. Neil Leach considers the city as a “swarm intelligence”,[14] bringing forward the potential of developing urban form with computational method. Leach encourages swarm intelligence for the interactions between agents (parts), which "offers behavioral translations of topology and geometry",[15] while fractals, L-systems or cellular automata are all constrained by some limitation. However, although swarm intelligence is based on the interaction of individual agents, it is always treated as a whole; all cells of CA are fixed in the background grid, which is also a whole. For fractals and L-systems, they can be subdivided into infinite parts, a transcendent whole where all parts grown from still exist. In the mereological sense, none of these cases can escape the shadow of the whole – strictly speaking, they are part-to-whole relations. To discuss the part-to-part relation in more depth, more investigation is needed to clarify the concept of part.

In *The Democracy of Objects* (2011), Levi Bryant claims that objects constitute a larger object by establishing relations with others, but this doesn't alter the existence of objects, as he says, "all objects equally exist, but not all objects exist equally." In Bryant's discourse, this independence suggests the dissolution of the whole. Bryant proposes a concept of "regimes of attraction", that includes the "endo-relation" and the "exo-relation". The endo-relation indicates that the proper being of an object consists of its powers or what an object can do", not the "qualities" emerging within an exo-relation. An object possesses "volcanic powers", the stabilisation of the regime of attraction actualises it into a specific state.[16] The concept of the whole reduces objects to this state, which displays only a section of their proper beings. The concept of regimes of attraction is against this reduction.

The regime of attraction can be linked to the notion of "assemblage" from Manuel DeLanda, however, there is a distinction between the two. Assemblage holds only the relation of exteriority, whereas regime of attraction maintains both relations of interiority and exteriority. In *Assemblage Theory* (2016), DeLanda reassembled the concept "assemblage", which was originated from the French *agencement*. Created by Gilles Deleuze and Félix Guattari, this original term refers to the following meanings: the "action of matching or fitting together a set of components" – the process, and the "result of such an action" – the product.

DeLanda emphasised two aspects, heterogeneity and relations. As he indicated, the "contrast between filiations and alliances"[17] can be described in other words as intrinsic and extrinsic relations.

The nature of these relations has different influences on the components. The intrinsic relation tends to define the identities of all the parts and fix them into exact location, while the extrinsic relation connects the parts in exteriority – without interfering with their identities. DeLanda summarised four characteristics of assemblage: 1) individuality, an assemblage is an individual entity, despite different scale or different number of components; 2) heterogeneity, components of an assemblage are always heterogeneous; 3) composable, assemblages can be composed into another assemblage; 4) bilateral-interactivity, an assemblage emerges from parts interactions, it also passes influences on parts.[18]

DeLanda then moved on to the two parameters of assemblage. The first parameter is directed toward the whole, the "degree of territorialisation and deterritorialisation", meaning how much the whole "homogenises" its component parts. The second parameter is directed toward the parts, the "degree of coding and decoding", meaning how much the identities of parts are fixed by the rules of the whole. The concept of assemblage provides us a new lens of investigating these mereological relations. With this model, the heterogeneities and particularity of parts are fully respected. The wholes become immanent, individual entities, existing "alongside the parts in the same ontological plane",[19] while parts in a whole are included in the whole but not belonging to it, and according to Bryant's discourse, the absence of belonging dispelled the existence of the whole.[20]

From the study of regime of attraction and assemblage, this essay proposes a new concept – "the ultimate parts" – in which a proper "part-to-part without whole" is embedded. A part (P) horizontally interacts with its neighbouring parts (Pn), with parts of neighbouring parts (Pnp), as well as interacting downwardly with parts that compose it (Pp) and upwardly with wholes it is constituting which are also parts (Pw). This concept significantly increases the initiatives of parts and decreases the limitations and reductions of them. It doesn't deny the utilities of the whole, but considers the whole as another independent entity, another part. It's neither top-down, nor bottom-up, but projects all relations from a hierarchical structure to a comprehensive flattened structure. The ultimate parts concept provides a new perspective for observing relations between objects from a higher dimension.

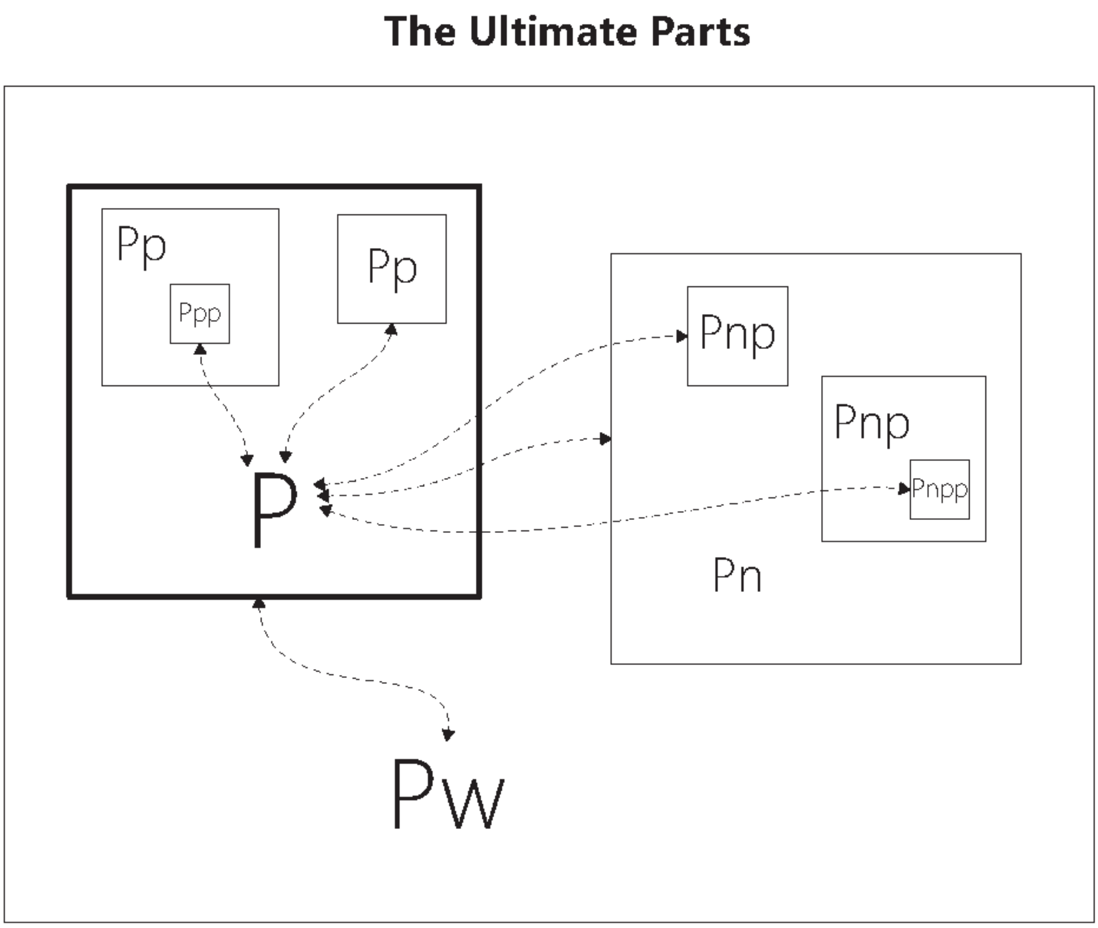


Figure 13 – Diagram of “The Ultimate Parts”. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

One application of this concept is TARSS (Tensegrity Adaptive Robotic Structure System), my research project in MArch Architectural Design in B-Pro at The Bartlett School of Architecture in 2017–2018. This project utilises the features of tensegrity structures of rigidity, flexibility and lightweight. The difference is that rather than fixing parts into a static posture and eliminating their movements, the project contrarily tries to increase the freedom of parts as much as possible. The tensile elements have the ability to adjust their lengths collaboratively to change the general shape of the aggregation. Reinforcement learning is employed to empower the parts with objective awareness. The training sessions were set up toward multiple objectives that are related to architectural concerns, including pathfinding, transformation, balance-keeping, self-assembling and structural load distributing. This approach brings obvious benefits, as architecture design in this sense is not only about an eventual result, but about the dynamic process of constantly responding to the environmental, spatial or functional requirements. The premise is to treat parts as ultimate parts whilst retaining their objectivity and being able to actively interact at all mereological levels without limitations.

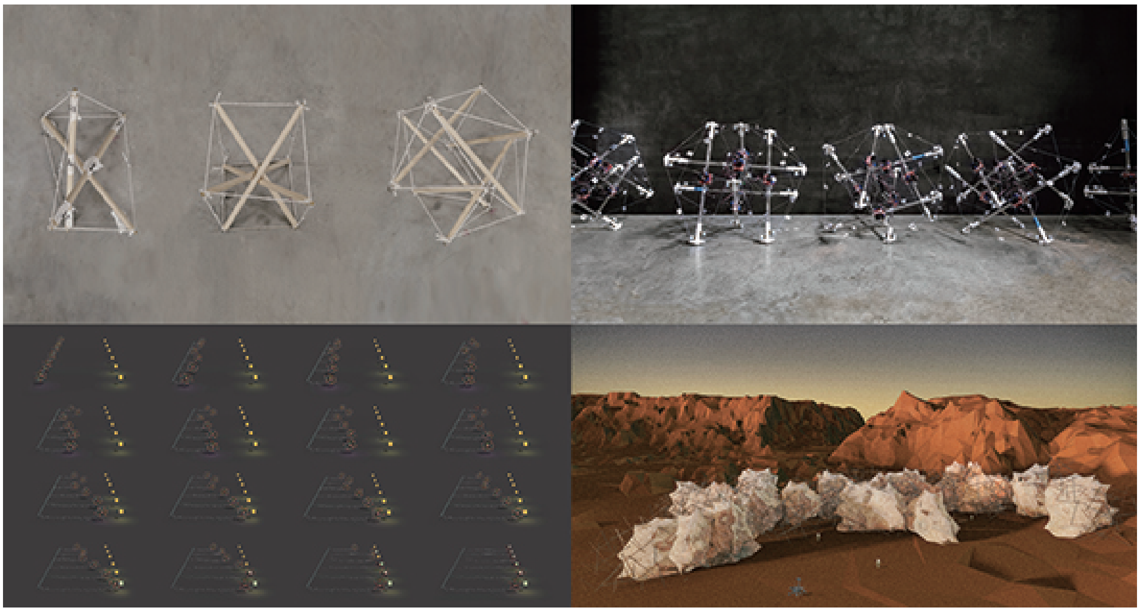


Figure 14 – Key images from the project TARSS. Image: Ziming He, Living Architecture Lab, RC3, MArch Architectural Design, The Bartlett School of Architecture, UCL, 2018.

The concept of ultimate parts brings forward a new relation of "part-to-part without whole". This new relation belongs to a higher dimension. The details and essence of objects are simultaneously displayed, without being obscured by the compositional structure. Analogised with spatial dimensions, a 3-dimensional cube simultaneously shows all its faces and interior in 4-dimensional space. The significance is that it opens vast new perspectives and operational methodologies in the architectural design realm. Especially with the advancement in robotics and artificial intelligence, this type of new relationship enables greater opportunitiesby regarding machines as characters with immense potential to work withus, instead of for us. The role of designers would be very much like"breeders of virtual forms",[21] who do not rule the form, but guide ittowards the demands. This moves away from anthropocentric design byovercoming part-to-whole with part-to-part.

Article 11 : Towards a Sympoietic Architecture: Codividual Sympoiesis as an Architectural Model

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“…the rigour of the architecture is concealed beneath the cunning arrangement of the disordered violences…”[1]

This essay investigates the potential of codividual sympoiesis as a mode of thinking overlapping ecological concepts with economics, contemporary philosophy, advanced research in computation and digital architecture. By extending Donna Haraway’s argument of “tentacular thinking” into architecture, it lays emphasis on a self-organising and sympoietic approach to architecture. Shifting focus from an object-oriented thinking to parts, it uses mereology, the study of part-hoods and compositions, as a methodology to understand a building as being composed of parts.

It argues the limits of autopoiesis as a system and conceptualises a new architectural computing system embracing spatial codividuality and sympoiesis as a necessity for an adaptive and networked existence through continued complex interactions among its components. It propagates codividual sympoiesis as a model for continuous discrete computation and automata, relevant in the present times of distributed and shared economies.

A notion of fusing parts is established to scale up the concept and to analyse the assemblages created over a steady sympoietic computational process, guided by mereology and the discrete model. It gives rise to new conceptions of space, with a multitude of situations offered by the system at any given instant. These sympoietic inter-relations between the parts can be used to steadily produce new relations and spatial knottings, going beyond the most limiting aspect of autopoiesis, enabling it to begin to produce similar patterns of relations.

Tentacular Thinking

This essay extends the conceptual idea of tentacular thinking,[2] propagated by Donna Haraway, into architecture. Tentacular thinking, as Haraway explains, is an ecological concept which is a metaphorical explanation for a nonlinear, multiple, networked existence. It elaborates on a biological idea that “we are not singular beings, but limbs in a complex, multi-species network of entwined ways of existing.” Haraway, being an ecological thinker, leads this notion of tentacular thinking to the idea of poiesis, which means the process of growth or creation and brings into discussion several ecological organisational concepts based on self-organisation and collective organisation, namely autopoiesis and sympoiesis. It propagates the notion that architecture can evolve and change within itself, be more sympoietic rather than autopoietic, and more connected and intertwined.

With the advent of distributed and participatory technologies, tentacularity offers a completely new formal thinking, one in which there is a shift from the object and towards the autonomy of parts. This shift towards part-thinking leads to a problem about how a building can be understood not as a whole, but on the basis of the inter-relationships between its composing parts. It can be understood as a mereological shift from global compositions to part-hoods and fusions triggering compositions.

A departure from the more simplified whole-oriented thinking, tentacular thinking comes about as a new perspective, as an alternative to traditional ideologies and thinking processes. In the present economic and societal context, within a decentralised, autonomous and more transparent organisational framework, stakeholders function in a form that is akin to multiple players forming a cat's cradle, a phenomenon which could be understood as being sympoietic. With increases in direct exchange, especially with the rise of blockchain and distributed platforms such as Airbnb, Uber, etc. in architecture, such participatory concepts push for new typologies and real estate models such as co-living and co-working spaces.

Fusion of Parts: Codividuality

In considering share-abilities and cooperative interactions between parts, the notions of a fusing part and a fused part emerge, giving rise to a multitude of possibilities spatially. Fusing parts fuse together to form a fused part which, at the same stage, behaves as another fusing part to perform more fusions with other fusing parts to form larger fused parts. The overlaps and the various assemblages of these parts gain relevance here, and this is what codividuality is all about.

As Haraway explains, it begins to matter "what relations relate relations."[3] Codividual comes about as a spatial condition that offers cooperative, co-living, co-working, co-existing living conditions. In the mereological sense, codividuality is about how fusing parts can combine to form a fused part, which in turn, can combine to form a larger fused part and so on. Conceptually, it can be understood that codividuality looks into an alternative method for the forming and fusing of spatial parts, thereby evolving a fusion of collectivist and individualist ideologies. It evolves as a form of architecture that is created from the interactions and fusion of different types of spaces to create a more connected and integrated environment. It offers the opportunity to develop new computing systems within architecture, allowing architectural systems to organise with automaton logic and behave as a sympoietic system. It calls for a rethinking of automata and computation.

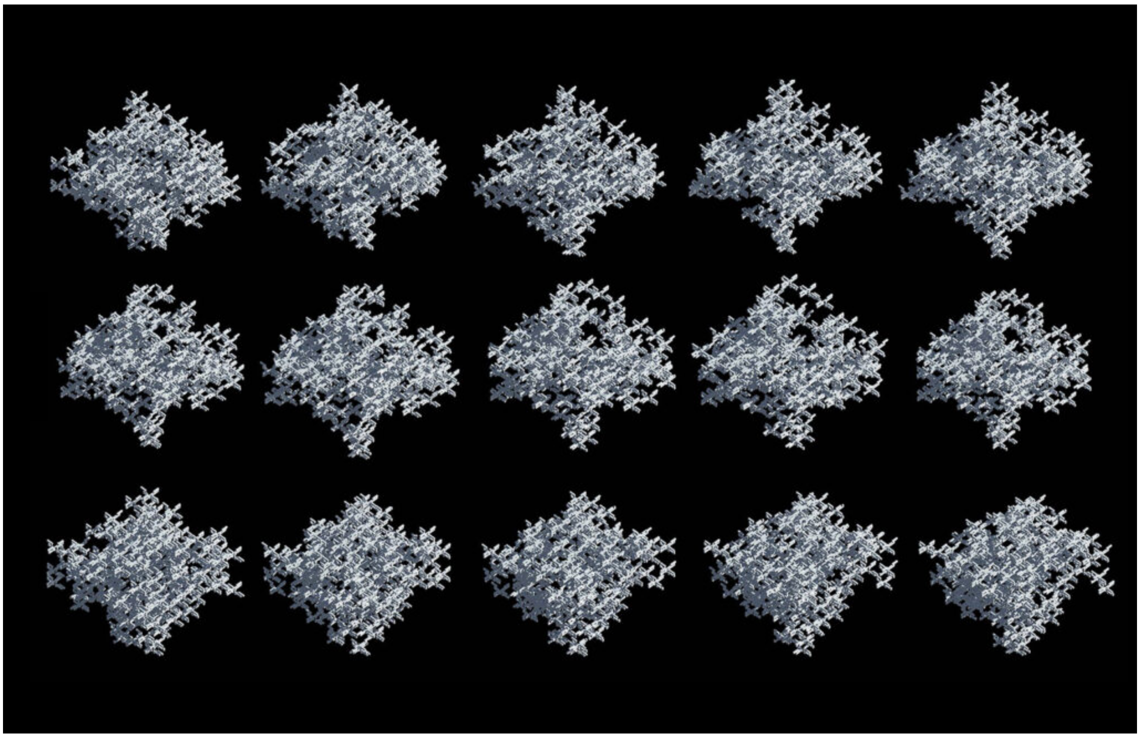


Figure 1 – Computational experiments in Tentacular Thinking. Image: Anthony Alvidrez, Shivang Bansal and Haochen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Codividual can be perceived as a spatial condition allowing for spatial connectivities and, in the mereological sense, as a part composed of parts; a part and its parts. What is crucial is the nature of the organisation of these parts. An understanding of the meaning and history of the organisational concepts of autopoiesis and sympoiesis brings out this nature.

Autopoiesis: Towards Assemblages of Parts

The concept of autopoiesis stems from biology. A neologism introduced by Humberto Maturana and Francisco Varela in 1980, autopoiesis highlights the self-producing nature of living systems. Maturana and Varela defined an autopoietic system as one that "continuously generates and specifies its own organisation through its operation as a system of production of its own components."[4] A union of the Greek terms – *autos*, meaning "self" and, *poiesis*, meaning "organisation" – autopoiesis came about as an answer to questions cropping up in the biological sciences pertaining to the organisation of living organisms. Autopoiesis was an attempt to resolve the confusion between biological processes that depend on history such as evolution and ontogenesis, in contrast with those that are independent of history, like individual organisation. It questioned the organisations of living systems which made them a whole.

Varela et al pointed out autonomy as the characteristic phenomenon arising from an autopoietic organisation; one that is a product of a recursive operation.[5] They described an autopoietic organisation as a unity; as a system, with an inherently invariant organisation. Autopoietic organisation can be understood as a circular organisation; as a system that is self-referential and closed. Jerome McGann, on the basis of his interpretation of Varela et al, described an autopoietic system as a "closed topological space, continuously generating and specifying its own organisation through its operation as a system of production of its own components, doing it in an endless turnover of components".[6]

What must be noted here is that the computational concept of self-reproducing automata is classically based on an understanding of a cell and its relation to the environment. This is akin to the conceptual premise of autopoiesis, which is the recursive interaction between the structure and its environment,[7] thus forming the system. It must be noted that both the concepts start with a biological understanding of systems and then extend the concept. A direct link can be observed between the works of von Neumann, and Maturana and Varela. Automata, therefore, can be seen as an autopoietic system.

The sociologist, Niklas Luhmann, took forward this concept into the domain of social systems. His theoretical basis for the social systems theory is that all social events depend on systems of communication. On delving into the history of social or societal differentiation, Luhmann observes that the organisation of societies is based on functional differentiation. A "functionally differentiated society", as he explains, comprises varying parallel functional systems that co-evolve as autonomous discourses. He discovers that each of these systems, through their own specific medium, evolve over time, following what Luhmann calls "self-descriptions", bringing out a sense of autonomy in that respective system.[8]

Following Maturana and Varela's explanation, an autopoietic organisation may be viewed as a composite unity, where internal interactions form the boundary through preferential neighbourhood interactions, and not external forces. It is this attribute of self-referential closure that Luhmann adopts in his framework. This closure maintains the social systems within and against an environment, culminating in order out of chaos.

The Limits of Autopoietic Thinking

Beth Dempster, as a contradiction to Maturana and Varela's proposition of autopoiesis, proposed a new concept for self-organising systems. She argues that heuristics based on the analogy of living systems are often incongruous and lead to misleading interpretations of complex systems. Besides, autopoietic systems tend to be homeostatic and are development oriented in their nature.[9] Being self-producing autonomous units "with self-defined spatial or temporal boundaries",[10] autopoietic systems show a centralised control system and are consequently efficient. At the same time, such systems tend to develop patterns and become foreseeable. It is this development-oriented, predictable and bounded nature of autopoietic systems that poses a problem when such systems are scaled up.

Autopoietic systems follow a dynamic process that allows them to continually reproduce a similar pattern of relations between their components. This is also true for the case of automata. Moreover, autopoietic systems produce their own boundaries. This is the most limiting aspect of these concepts.

Autopoietic systems do not instigate the autonomy of parts, as they evolve on a prescribed logic. Instead, a more interesting proposition is one in which the interacting parts instigate a kind of feedback mechanism within the parts, leading to a response that triggers another feedback mechanism, and so on. Mario Carpo's argument that in the domain of the digital, every consumer can be a producer, and that the state of permanent interactive variability offers endless possibilities for aggregating the judgement of many,[11] becomes relevant at this juncture. What holds true in the context of autopoiesis is Carpo's argument that fluctuations decrease only at an infinitely large scale, when the relations converge ideally into one design.

In the sympoietic context, however, this state of permanent interactive variability Carpo describes is an offer of the digital to incorporate endless externalised inputs.[12] The need for sympoiesis comes in here. Sympoiesis maintains a form of equilibrium or moderation all along, but also, at the same time, remains open to change. The permanent interactive variability not only offers a multitude of situations but also remains flexible.

Sympoiesis

The limits to autopoietic thinking is what forms the basis for Dempster's argument. In contradistinction to autopoiesis, she proposes a new concept that theorises on an "interpretation of ecosystems", which she calls sympoietic systems. Literally, sympoiesis means "collective creation or organisation". A neologism introduced by Dempster, the term, sympoiesis, explains the nature of living systems. Etymologically, it stems out from the Ancient Greek terms "□□□ (sún, "together" or "collective")" and "π□□□□□□ (poíesis, "creation, production")". As Dempster explains, these are "collectively producing systems, boundaryless systems."[13]

Sympoietic systems are boundary-less systems set apart from the autopoietic by "collective, amorphous qualities". Sympoietic systems do not follow a linear trajectory and do not have any particular state. They are homeorhetic, i.e., these systems are dynamical systems which return to a trajectory and not to a particular state.[14] Such systems are evolution-oriented in nature and have the potential for surprising change. As a result of the dynamic and complex interactions among components, these systems are capable of self-organisation. Sympoietic systems, as Donna Haraway points out, decentralise control and information",[15] which gets distributed over the components.

Sympoiesis can be understood simply as an act of "making-with".[16] The notion of sympoiesis gains importance in the context of ecological thinking. Donna Haraway points out that nothing or no system can reproduce or make itself, and therefore, nothing is really absolutely autopoietic or self-organising. Sympoiesis reflects the notion of "complex, dynamic, responsive, situated, historical systems." As Haraway explains, "sympoesis enlarges and displaces autopoesis and all other self-forming and self-sustaining system fantasies."[17]

Haraway describes sympoietic arrangements as "ecological assemblages".[18] In the purview of architecture, sympoiesis brings out a notion of an assemblage that could be understood as an architectural assemblage growing over sympoietic arrangements. Though sympoiesis is an ecological concept, what begins to work in the context of architecture is that the parts don't have to be strict and they aim to think plenty; they also have ethics and synergies among each other. In sympoietic systems, components strive to create synergies amongst them through a cooperation and a feedback mechanism. It is the linkages between the components that take centre stage in a sympoietic system, and not the boundaries. Extrapolating the notion of sympoiesis into the realm of architecture, these assemblages can be conceived in Haraway's words as "poly-spatial knottings", held together "contingently and dynamically" in "complex patternings".[19] What become critical are the intersections or overlaps or the areas of contact between the parts.

Sympoietic systems strategically occupy a niche between allopoiesis and autopoiesis, the two concepts proposed by Maturana and Varela. The three systems are differentiated by various degrees of organisational closure. Maturana and Varela elaborate on a binary notion of organisationally open and closed systems. Sympoiesis, as Dempster explains steps in as a system that depends on external sources, but at the same time it limits these inputs in a "self-determined manner". It is neither closed nor open; it is "organisationally ajar".[20] However, these systems must be understood as only idealised sketches of particular scenarios. No system in reality must be expected to strictly adhere to these descriptions but rather lie on a continuum with the two idealised situations as its extremes.

It is this argument that is critical. In the context of architecture and urban design, what potentially fits is a hybrid model that lies on the continuum of autopoiesis and sympoiesis. While autopoiesis can guide the arrangement or growth of the system at the macro level, sympoiesis must and should step in in order to trigger a feedback or a circular mechanism within the system to respond to externalities. What can be envisaged is therefore a system wherein the autopoietic power of a system constantly attempts to optimise the system towards forming a boundary, and simultaneously the sympoietic power of the system attempts to trigger the system for a more networked, decentralised growth and existence, and therefore, creates a situation where both the powers attempt to push the system towards an equilibrium.

Towards Poly-Spatial Knottings

In sympoiesis, parts do not precede parts. There is nothing like an initial situation or a final situation. Parts begin to make each other through "semiotic material involution out of the beings of previous such entanglements"[21] or fused situations. In order to define codividuality and to identify differences, an understanding of classifying precedents is important. The first move is a simple shift from an object-oriented thinking to a parts-oriented thinking. Buildings are classified as having a dividual, individual and codividual character from the point of view of structure, navigation and program.

Codividual is a spatial condition that promotes shared spatial connections, internally or externally, essentially portraying parts composed of parts, which behave as one fused part or multiple fused parts. The fused situations fulfil the condition for codividuality as the groupings form a new inseparable part – one that is no longer understood as two parts, but as one part, which is open to fuse with another part.

Fused Compositions

Delving into architectural history, one can see very few attempts in the past by architects and urban designers towards spatial integration by sympoietic means. However a sympoietic drive can be seen in the works of the urban planner Sir Patrick Geddes. He was against the grid-iron plan for cities and practised an approach of “conservative surgery” which involved a detailed understanding of the existing physical, social and symbolic landscapes of a site. For instance, in the plan for the city of Tel Aviv in Israel (1925–1929), Geddes stitches together the various nodes of the existing town akin to assemblages to form urban situations like boulevards, thereby activating those nodes and the connecting paths.

Fumihiko Maki and Masato Oktaka also identify three broad collective forms, namely, compositional form, megastructures and group forms. Maki underscores the importance of linkages and emphasises the need for making “comprehensible links” between discrete elements in urban design. He further explains that the urban is made from a combination of discrete forms and articulated large forms and is therefore, a collective form and “linking and disclosing linkage (articulation of the large entity)”[22] are of primary importance in the making of the collective form. He classifies these linkages into operational categories on the basis of their performance between the interacting parts.

Building upon Maki’s and Ohtaka’s theory of “collective form”, it is useful to appreciate that the architecture of a building can be thought of as a separate entity, and consequently there is an “inadequacy of spatial language to make meaningful urban environment.”[23] Sympoiesis comes out through this notion of understanding the urban environment as an interactive fabric between the building and the context. Maki and Ohtaka also make an important comment that the evolution of architectural theory has been restricted to the building and describe collective forms as a concept which goes beyond the building. Collective forms can have a sympoietic or an autopoietic nature, which is determined by the organisational principles of the collective form. Sympoietic collective forms not only can go beyond the building, but also weave a fabric of interaction with the context. Although a number of modern cases of collective forms exist, most of the traditional examples of collective forms, however, have evolved into collective forms over time, albeit unintentionally.

Figure 2 – Sympoietic urban fusion in the Uffizi corridor by Giorgio Vasari. Image: Shivang Bansal, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2018-19.

The Corridor by Giorgio Vasari

An important case of an early endeavour in designing a collective form at an urban scale is Corridoio Vasariano by Giorgio Vasari in Florence, builtin the year 1564. It can be understood as a spatial continuum thatconnects through the numerous important buildings or nodes within thecity through a built corridor, resulting in a collective form. According to Michael Dennis, Vasari's Corridor, in its absolute sense, is a Renaissance "insert" into the "fundamentally medieval fabric of central Florence".[24] As Dennis writes in *The Uffizi: Museum as Urban Design* (1980),

"...Each building has its own identity and internal logic but is also simultaneously a fragment of a larger urban organisation; thus each is both complete and incomplete. And though a given building may be a type, it is always deformed, never a pure type. Neither pure object nor pure texture, it has characteristics of both – an ambiguous building that was, and still is, multifunctional..."[25]

Dennis's description for the design of the Vasari's Corridor brings out the notion of spatial fusion of buildings as parts. The Corridor succeeds as an urban insert and this is primarily for two reasons. At first, it maintains the existing conditions and is successful in acclimatising to the context it is placed in. Secondly, it simultaneously functions on several varying scales, from that of the individual using the Corridor to the larger scale of the fabric through which it passes. The Vasari's Corridor is a sympoietic urban fusion – one that is a culmination of the effect of local conditions.

Stan Allen, in contrast to compositions, presents a completely inverted concept for urban agglomerations. His concept of field configurations reflects a bottom-up phenomena. In his view, the design must necessarily reflect the "complex and dynamic behaviours of architecture's users".[26] Through sympoiesis, the internal interaction of parts becomes decisive and they become relevant as they become the design drivers and the overall formation remains fluid and a result of the interactions between the internal parts.

Figure 3 – Poly-spatial knottings composed of parts. Image: Anthony Alvidrez, Shivang Bansal and Haochen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Towards a Sympoietic Architecture

Another important aspect that forms a basis for the sympoietic argument is the relevance of information in systems. While Maturana and Varela explain that information must be irrelevant to self-producing systems since it is an extrinsically defined quantity, Dempster lays great emphasis on the relevance of information in sympoietic systems. Her explanation on the relevance of information is that it potentially carries a message or a meaning for a recipient. Information, therefore, is dependent on the context and recipient, but Stafford Beer hints that it is also "observer dependent".[27]

In the architectural domain, it signifies that information or external data input holds no relevance in an autopoietic system. The system grows purely on the basis of the encoded logic and part-to-part organisational relations, and is unrestricted and free from any possible input. However, information or data in the sympoietic paradigm gains relevance as it activates the system as a continuous flux of information guiding its organisation. This relates to the concepts of reinforced machine learning, wherein the system learns by heuristics to evolve by adapting to changing conditions, and by also producing new ones, albeit it comes with an inherent bias.

The Economic Offer of the Codividual

From an economic lens, the concept of sympoiesis does not exist at the moment. However, with the rise in participatory processes within the economy and the advent of blockchain, it shows immense potential in architecture. Elinor Ostrom's work on the role of commons in decision-making influences the work of David Rozas, who researches on a model of blockchain-based commons governance. He envisages a system which is decentralised, autonomous, distributed and transparent, a more democratic system where each individual plays his/her own role.[28] This idea is about bringing a more sympoietic kind of drive to blockchain. Sympoietic systems are based on a model that is akin to a commons-oriented or a blockchain-based economy that functions like a cat's cradle with its multiple stakeholders being interdependent on each other. And as Jose Sanchez points out, it is the power of the discrete, interdependent system that makes this architecture possible. According to him, it offers a "participatory framework for collective production".[29]

Figure 4 – Fused parthoods over sympoietic interactions. Physical

model Comata, Anthony Alvidrez, Shivang Bansal and Haochen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019. Image: Rasa Navasaityte.

The fusion of parts leads to the creation of parts such that the sum of the parts becomes greater than the whole. A codividual sympoietic model can potentially resolve the housing crisis since it flips the economic model to a bottom-up approach. With tokenisation, autonomous automatisation, decentralisation of power and transparency, this blockchain-based codividual model can compete with traditional real estate models, thereby resulting in more equitable and fair-minded forms of housing. As Lohry and Bodell point out, such models can reduce personal risk and also make livelihoods more economical and "community-oriented".[30]

Conclusion

The ecological framework of the concept of poiesis, as already outlined, is based on the growth from the organisation of elements. In the context of autopoiesis and sympoiesis, it can be observed that "part-to-part" and even "part-to-whole" conditions gain significant relevance in these concepts. An appreciation of these conditions, therefore, becomes relevant to understand these kinds of notions. The idea of components, as described by Dempster and Haraway in the purview of sympoiesis, and Jerome McGann in the autopoietic context, could be extended to architecture in the form of part-thinking.

However, a mereological approach begins with existing entities or "sympoietic interactions" and proceeds further with a description of their clusters, groupings and collectives. Through codividual sympoiesis, the whole gets distributed all over the parts.[31] In this system, the discreteness of parts is never just discrete. It goes beyond the participating entities and the environment. In line with Daniel Koehler's argument, the autonomy of the part ceases to be defined just as a self-contained object. It goes beyond it and begins to be defined "around a ratio of a reality, a point of view, a filter or a perspective"[32].

Sympoiesis evolves out of competitive or cooperative interactions of parts. As in ecology, these parts play symbionts to each other, in diverse kinds of relationalities and with varying degrees of openness to attachments and assemblages with other fusing parts depending on the number of embedded brains and the potential connectors. Traditionally, architecture is parasitic. When the aesthetic or the overall form drives the architecture, architectural elements act as a host for other architectural elements to attach to depending on composition. In sympoiesis, there is no host and no parasite. It inverts the ideology of modernism, beginning with not a composition but actually evolving a composition of "webbed patterns of situated and dynamic dilemmas" over symbiotic interaction. Furthermore, increasingly complex levels of quasi-individuality of parts come out of this process of codividual sympoiesis. It gives an outlook of a collective and still retains the identity of the individual. It can simply be called multi-species architecture or becoming-with architecture.

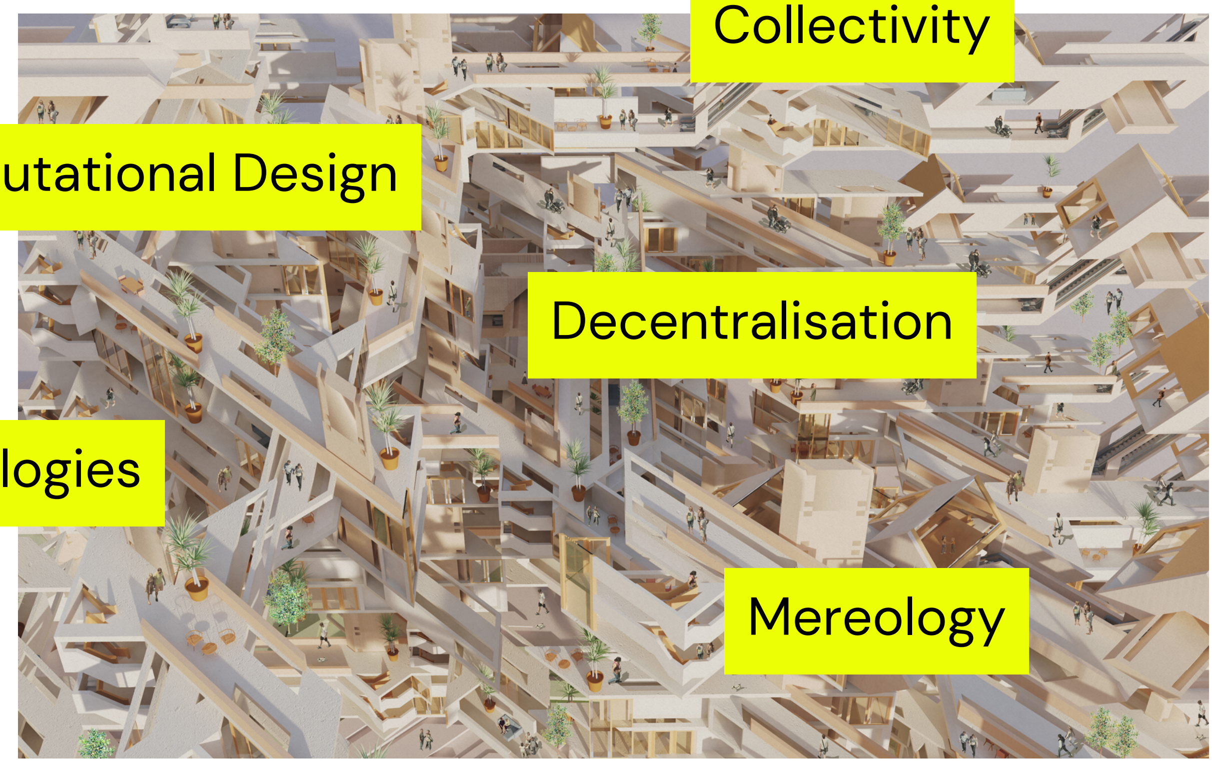
Figure 5 – Sympoietic Assemblages of Parts. Physical model Comata, Anthony Alvidrez, Shivang Bansal and Haochen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019. Image: Rasa Navasaityte.

Talking of transdisciplinary ecologies and architecture, we can foresee string figures tying together human and nonhuman ecologies,architecture, technologies, sustainability, and more. This also gives rise toa notion of ecological fusion of spatial conditions such as daylight andventilation, in addition to physical fusion of parts. Codividual sympoiesis,thus, even shows potential for a nested codividual situation, in that theparts sympoietically fuse over different spatial functions.

Going over sympoiesis and mereology, it makes sense to look for parts which fuse to evolve fused parts; to look for architecture through which architecture is evolved; to look for a codividuality with which another codividuality is evolved. From a mereological point of view, in a system in which the external condition overlaps with an internal part in the search for another component, to give rise to a new spatial condition over the fusion of parts could be understood as codividual sympoiesis. Codividual sympoiesis is therefore about computing a polyphony, and not orchestrating a cacophony.

Article 12 : Codividual Architecture within Decentralised Autonomous Systems

Architecture
Autonomy
Collectivity
Computational Design
Decentralisation
Mereologies
Mereology



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In mereology, the distinction of “dependent” or “independent” could be used to describe the relationship between parts and wholes. Using a mereological description, individuals can be seen as self-determining entities independently identified by themselves as a whole. On the other hand, the identities of collectives are determined by their group members which participate in a whole. Therefore, based on parthood theory, an individual could be defined as a self-determined “one in a whole”; in contrast, collectives could be seen as “a part within a whole”. Following the mereological logic, this paper surveys the new term “codividuality”, a word consisting of the combined meaning of “collective” and “individuality”. Codividuality preserves the intermediate values of individualism and collectivism. It consists of the notion of share-ability benefited from collectivism, and is merged with the idea of self-existence inspired by individualism. The characterisation of codividuality starts from individuals that share features, and are grouped, merging with other groups to compose new clusters.

Fusion

“Codividuals” could also be translated into “parts within parts”. Based on this part-to-part relation, codividuals in the sense of composition begin with existing individuals and then collectives of self-identified parts. Parts are discrete, but also participating entities[2] in an evolving self-organising system. Unlike individuals’ self-determination, parts’ identities contribute by participating, forming a strong correlation in-between parts but preserving autonomy of parts. In codividuality, each individualistic entity obtains the potential of state-transforming by sharing its identity with others; as such, all parts are able to translate one another, and are irreducible to their in-between relationship. From an ontological perspective, the existence of a part is not from adding a new object but by sharing features to fuse itself into a new part. A new part does not contribute by increasing an entity’s quantity but through a dynamic overlap transforming over time. Since the involved entities fuse into new collectives, the compositing group will simultaneously change its form by corresponding to sharing features; as such, codividuality could be seen as an autonomous fusion.

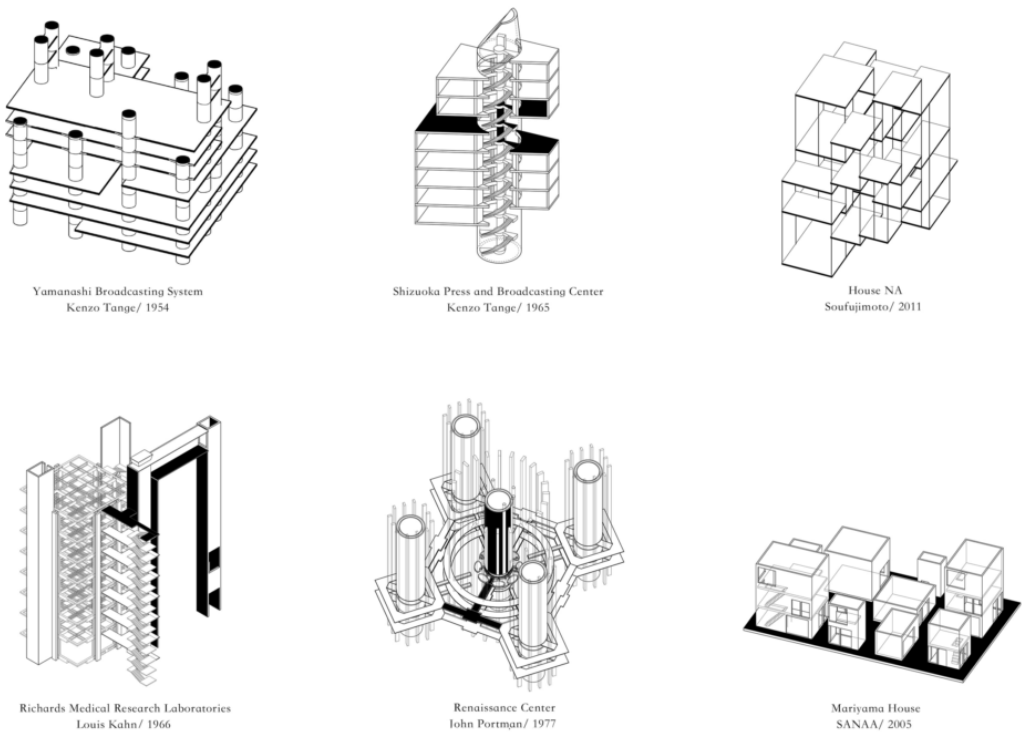


Figure 1 – Mereological drawings of the chosen Precedents, bringing out the individual, dividual and codividual nature of buildings. Image: Hao-Chen Huang.

Metabolism: As One in Whole

According to the definition of individualism, each individual has its own autonomous identity and the connectivity between individuals is loose. In architecture, social connectivity provides insight on the relationship of spatial sequences within cultural patterns. Metabolism, as an experimental architectural movement in post-war Japan, emerged with a noticeable individualist approach, advocating individual mobility and liberty. Looking at the configurations and spatial characteristics in Metabolist architecture, it is easy to perceive the features of “unit” and “megastructure”[3] as the major architectural elements in the composition, showing the individualistic characterisation in spatial patterns. Megastructure as an unchangeable large-scale infrastructure conceptually served to establish a comprehensible community structure. The unit as a structural boundary reinforced the identity of individuals in the whole community.

The Nakagin Capsule Tower (1970) by Kisho Kurokawa is a rare built example of Metabolism. It is a residential building consisting of two reinforced concrete towers, and the functional equipment is integrated into the megastructure forming a system of a core tower that serves its ancillary spaces. The functional programmes required for the served spaces are extended from the core where the structure and pipes are integrated. The identical, isolated units contain everything to meet basic human needs in daily life, which expresses the idea of individualism in architecture that is aimed for a large number of habitants. The independent individual capsules create a maximum amount of private space with little social connectivity to neighbours.

Constructivism: As Parts in Whole

Collectivism could be applied to a society in which individuals tie themselves together into a cohesion which obtains the attributes of dependence, sharing and collective benefit. This is aligned to the principles of constructivism, proposing the collective spatial order to encourage human interaction and generate collective consciousness. In contrast to the Metabolists, constructivist architecture underlined spatial arrangements for public space within compressed spatial functions that enable a collective identification.

The Narkomfin Building (1928–1932) by OSA Group is one of the few realised constructivist projects. The building is a six-story apartment located in a long block designed as a “social condenser”.[4] It consists of multiple social functions that correspond to specific functional and constructive norms for working and living space within whole community. The main building is a mix-use compound with one part for individual space and another designed as collective space. The private and common space are linked by an exterior walkway as a communal rooftop garden. There are 54 living units, and each of them only contain bedroom and bathroom. Each flat could be divided into two, one in which contains a playground and kitchen; the other one, a collective function area, which consists of garden, library and gymnasium. The corridors linking the flats are wide and open, appearing as an urban street to encourage inhabitants to stop and communicate with their neighbours.

Compared with the Nagakin Capsule Tower, the concept behind the spatial arrangement of Narkomfin Building is the collectivism of all needed programs. The large-scale collective was proposed as a means to replicate the concept of the village in the city. Practically this allows for a shrinking of the percentage of private space while stimulating the social interaction within the collective living space. The concept of amplifying communal space aligns to the constructivist movement through the concept of reinventing people's daily life by new socialist experimental buildings, reinforcing the identity of collectives within the whole community.

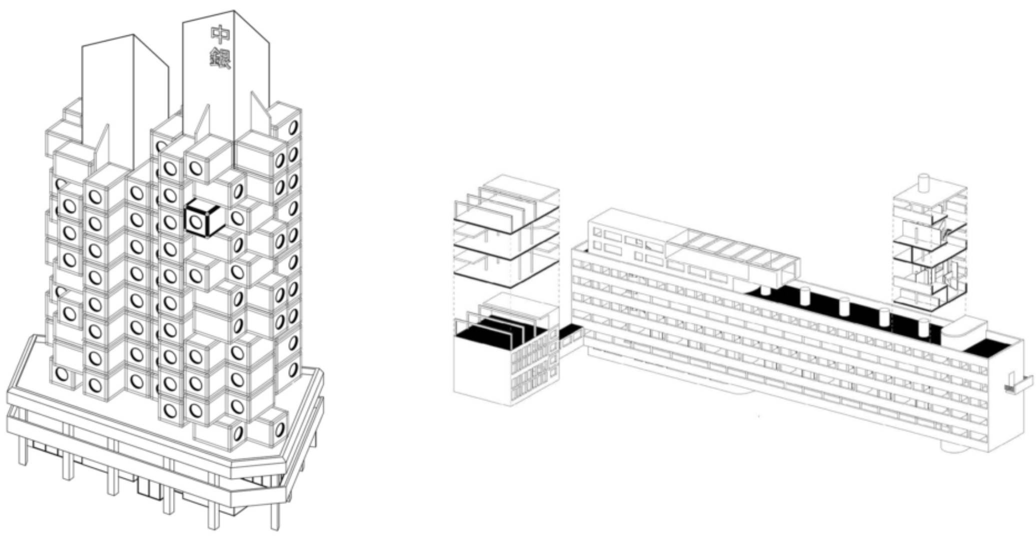


Figure 2 – (left) the Nakagin Tower metabolized by individualist parts; (right) the Narkofim constructed with collectivist parts. Image: Hao Chen Huang.

Codividuality: As Parts in Parts

In architecture, the word "codividuality" originally emerged in the Japanese architectural exhibition House Vision (2019) to refer to collective living in terms of the sharing economy, delivering a social meaning: "creating a new response to shared-living in the age of post-individualism".[5] Economically speaking, codividuality expresses the notion of share-ability in sense of sharing value and ownership. Moreover, it offers a participatory democracy for spatial use in relationship to changing social structures and practices. The architectural applications of codividuality are not merely about combined private space with shared public facilities but reveal a new reality that promotes accessibility and sustainability in multiple dimensions, including spatial use, economy and ecology.

Share House LT Josai (2013) is a collective-living project in Japan, offering an alternative for urban living in the twenty-first century sharing economy. Due to the change of demographic structure and rapidly rising house prices, Naruse Inokuma Architects created an opportunity to continually share spaces with unrelated people by creating an interactive living community in a two-and-a-half-story house. The 7.2 square meter individual rooms are three-dimensionally arranged across the two and a half levels. Between the bedrooms are the shared spaces, including a void area and an open plan living platform and kitchen that extend toward identical private rooms. The juxtaposition of private and communal spaces creates a new spatial configuration and an innovative living model in the sharing economy. Codividuality obtains individuals' autonomy and, on the other hand, encourages collective interaction. It is not an opposition to individualism nor a replication of collectivism, but a merged concept starting from individualism, then juxtaposing against the notion of collectivism.

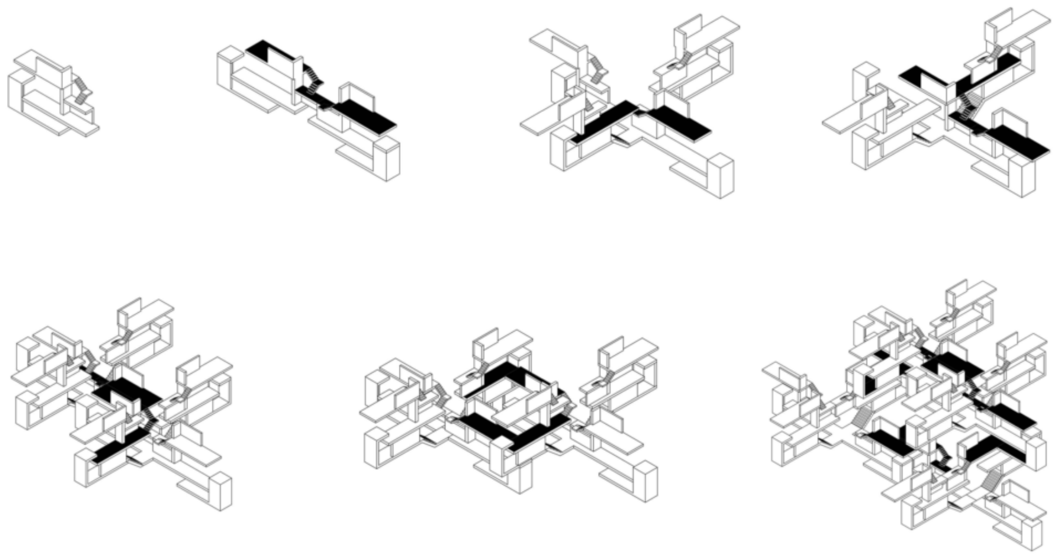


Figure 3 – Fusion of parts. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Autonomy of Parts

In contemporary philosophy, "Object Oriented Ontology" (OOO)[6] proposes a non-human way of thinking, unshackling objects from the burden of dominant ideologies. Objects are withdrawn from human perception, thereby containing the autonomy and irreducibility of substance. Accordingly, what this autonomy is based on is the independence of the object itself. An individual object is not reliant on any other objects, including humans. Objects exist whether we are aware of them or not. Objects do not need to passively rely on human cognition to represent themselves, but self-evidently and equally stand in the world.

OOO enables a transition in architectural meaning from architecture as autonomous objects to interactive relationships between object and field, where indirect relations between autonomous objects are observed. In an ecological sense, the reason behind this shift could be understood as an irreducibility of the architectural relationship within the environment; in other words, an architectural object cannot be withdrawn from its relation to context. As Timothy Morton writes, "all the relations between objects and within them also count as objects”,[7] and David Ruy states in his recent essay, “the strange, withdrawn interaction between objects sometimes brings forth a new object.”[8] Ruy emphasises the relation between objects based on a dynamic composition interacted with by individuals that is not a direct translation of nature.

In an object-orientated ontology, architecture is not merely an individual complete object but fused parts. This could be translated into a mereological notion of shifting from wholeness to parts. As a starting point for a design methodology, extracting elements from buildings represents loosening the more rigid system found in a modernist framework, by understanding architectural parts as autonomous and self-contained. Autonomous architectural elements cannot be reduced to the individual parts that make up the whole. This shift opens up an unprecedented territory in architectural discourse. Autonomous architectural parts now can participate in a non-linear system involving not only input or output, beginning or end, or cause or result; architecture can be understood as part of a process.

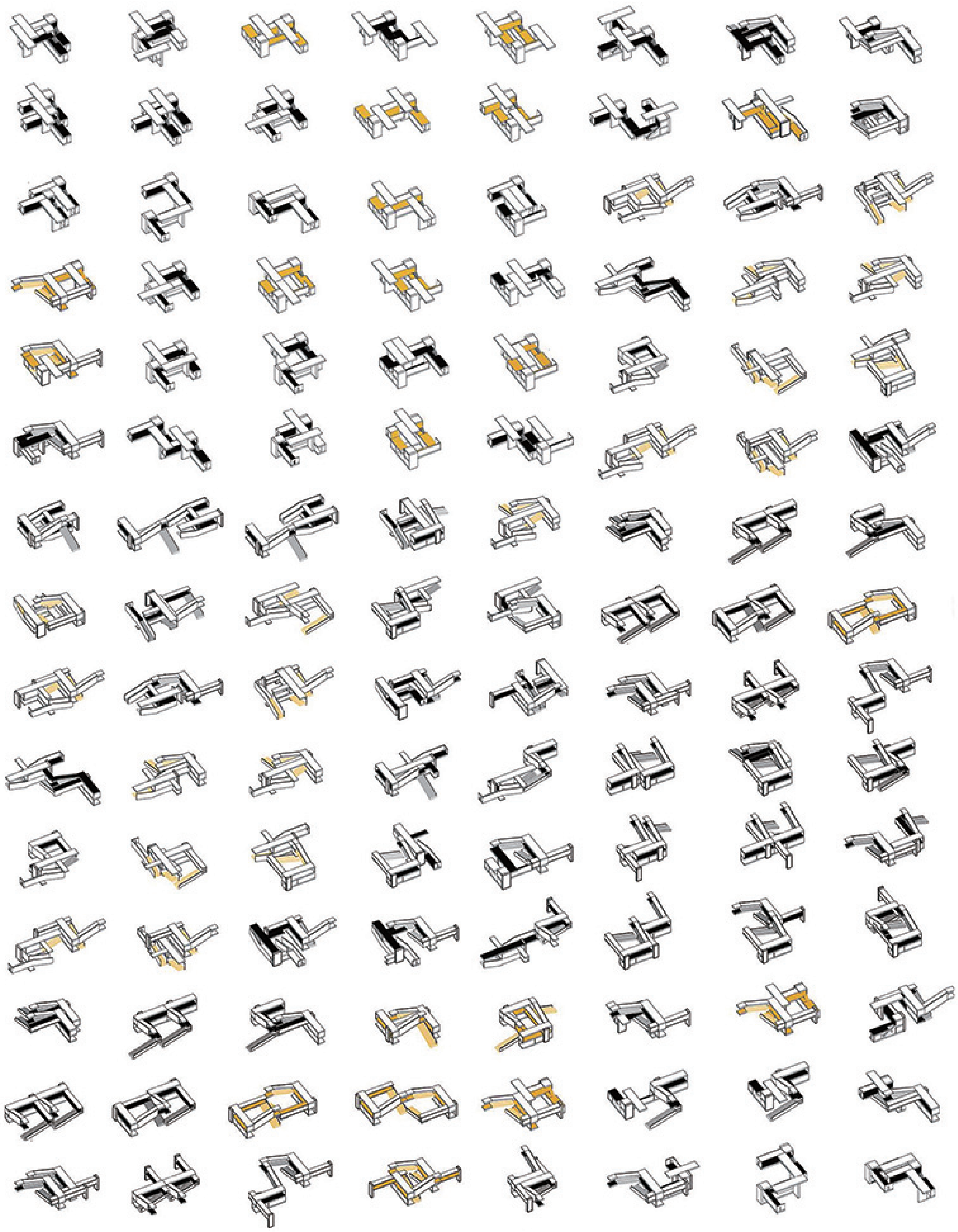


Figure 4 – Sampling of infinite codividual parts shown as yellow. Parts with different states showing the machine learning process of identifying codividual combination. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Architecture in the Sharing Economy

The rise of the sharing economy in the past decade has provided alternatives to the traditional service economy, allowing people to share and monetise their private property and shift thinking around privacy. In this context the following question arises: how could mereological architecture reveal new potentials beyond the inhabitation of buildings by engaging with the sharing economy? Due to the financialisation of the housing market and, simultaneously, the standardisation and lowering of quality of housing standards due to deregulation of the market, this question is even more pressing. Furthermore the bureaucracy of the planning system limits the architectural designing process by slowing development down and restricting innovation. In this context the reconfiguration of housing to emphasise collective space could be an alternative living model, alongside financial solutions such as shared ownership.

Decentralised Autonomous Organisation

The notion of a Decentralised Autonomous Organisation (DAO) seems fitting for furthering this discussion. In economic and technological terms, DAO is a digital organisation based on blockchain technologies, offering a decentralised economic model. As an alternative to centralised economic structures within a capitalist system, DAO benefits from blockchain technology as a digital tool for achieving a more transparent, accessible and sustainable economic infrastructure. This involves shifting decision-making away from centralised control and giving the authority to individual agents within the system.

In the Medium article “The Meaning of Decentralisation” by Vitalik Buterin, Buterin describes a decentralised system as a collective of individual entities that operate locally and self-organise, which supports diversity. Distribution enables a whole to be discretised into parts that interact in a dynamic computing system that evaluates internal and external connectivity between parts.[9] Through continuous interaction, autonomous discrete entities occasionally form chains of connectivity. In this process the quantities of parts at junctions continuously change. Over time patterns emerge according to how entities organise both locally and globally. Local patterns internally influence a collective while global patterns influence between collectives – or externally in a field of patterns – similar to Stan Allen’s notion of a “field condition”.[10] This creates global complexity while sustaining autonomy through local connectivity.

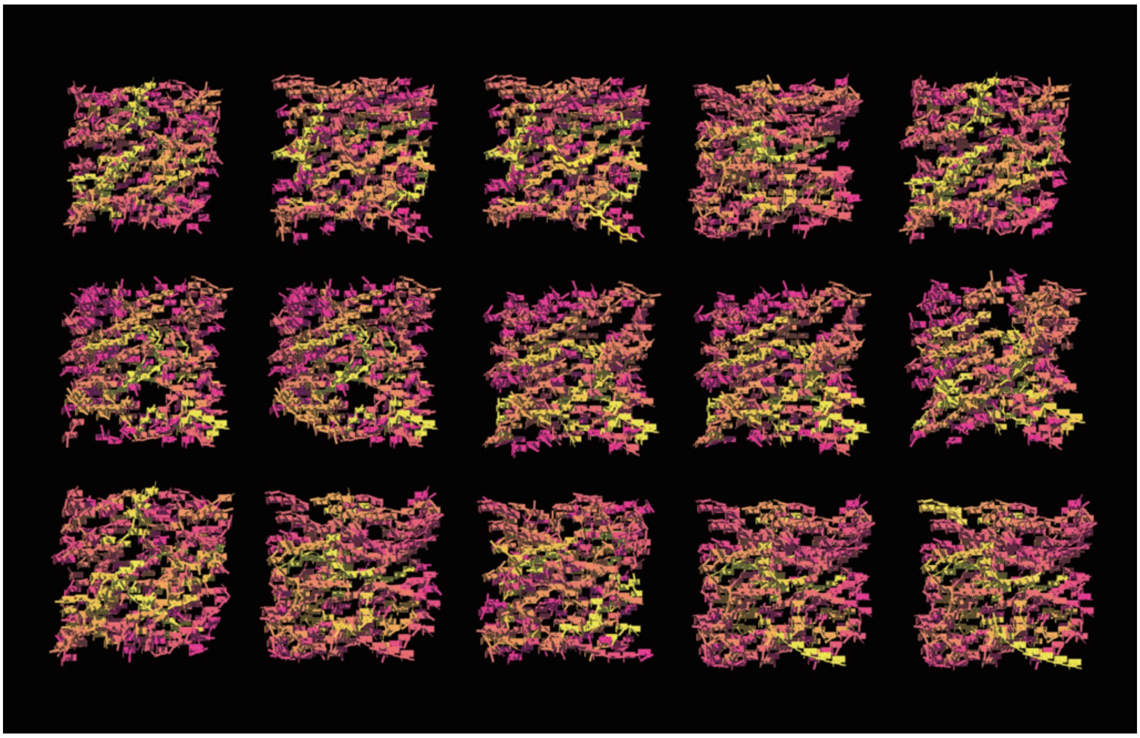


Figure 5 – Simulations of the interlocking chains training a machine learning model. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Distributing Codividuality

Codividuality could be seen as a post-individualism, where a diverse self-organising system withdraws power from capitalist authorities. The process of decentralisation characteristic of DAO is key to codividuality for it allows repeated patterns to form in a connected network. Architecturally, in codividual space each spatial unit consists of an open-ended program and self-contained structure, which means that architectural elements such as walls or slabs exist not for a specific function but serve a non-representational configuration.

Through computing codividual connectivity, autonomous spatial units start to overlap with other units, generating varying states of spatial use and non-linear circulation. What this distribution process offers is an expanded field of spatial iterations, using computation to respond to changes in quantity or type of inhabitants. In this open-ended system, codividual parts provide each spatial participant the capability to overcome the limitation of scalability through autonomous interconnection supported by a distributed database.

Unlike conventional planning in a modernist framework, codividual space does not aim for a module system that is used for the arrangement of programme, navigation or structure but for a non-figurative three-dimensional spatial sequence. The interconnections between parts and the field enable scalability from the smaller scale of spatial layouts towards large-scale urban formations. This large-scale fusion of codividual space generates a more fragmented, heterogeneous and interconnected spatial order, balancing collective benefit and individual freedom. In this shifting towards heterogeneity, codividuality opens a new paradigm of architecture in the age of the sharing economy.

Figure 6 – Perspective of a codividual building proposal for a site in Lisbon. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Figure 7 – Perspective view into a codividual space offering a 3dimensional urbanity. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

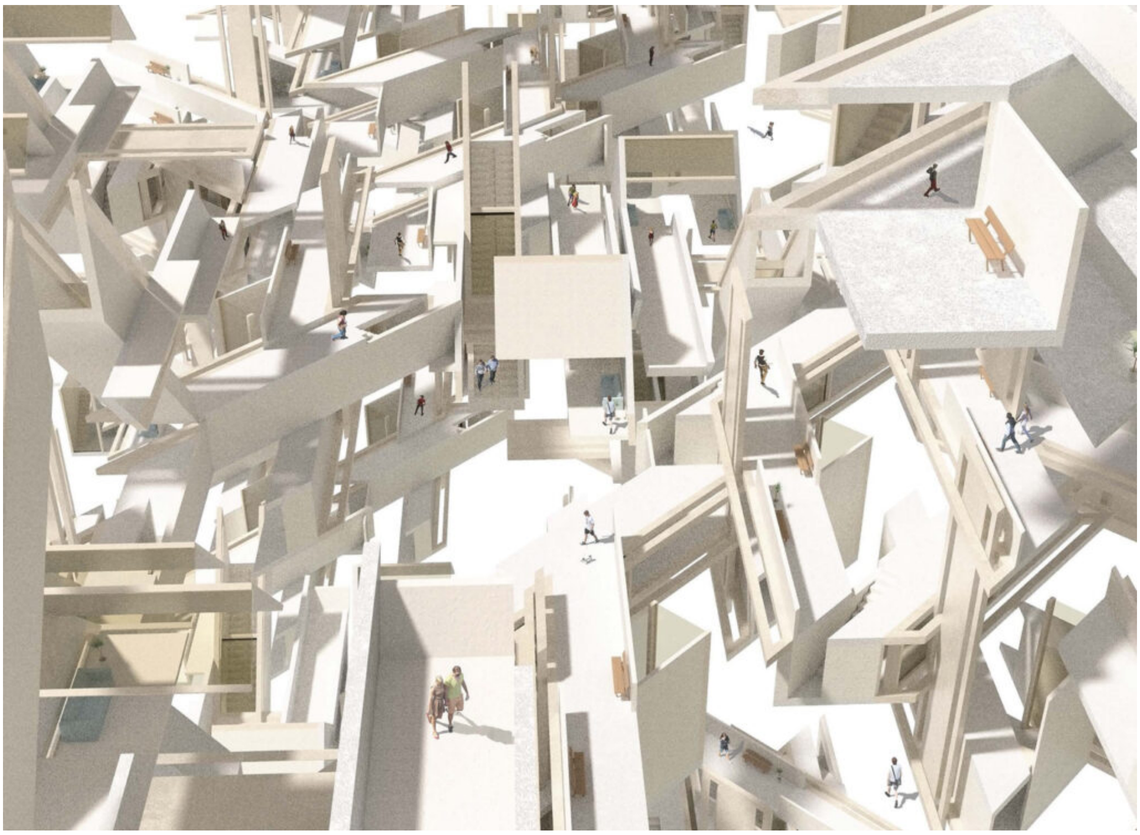


Figure 08 – Close-up into a codividual living area. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

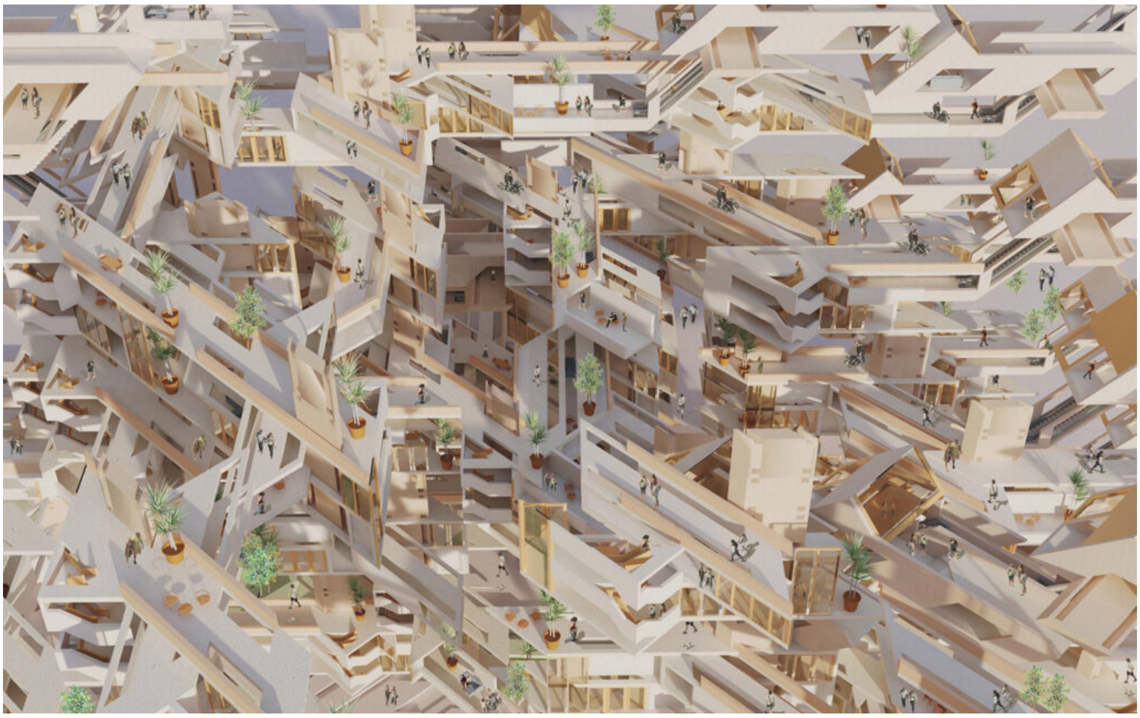


Figure 09 – View into a codividual interiority. Codividual aesthetics forming a plural space. Image: Comata, Anthony Alvidrez, Shivang Bansal, and Hao-Chen Huang, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2019.

Article 13 : Synthesising Hyperumwelten

Architecture

Building

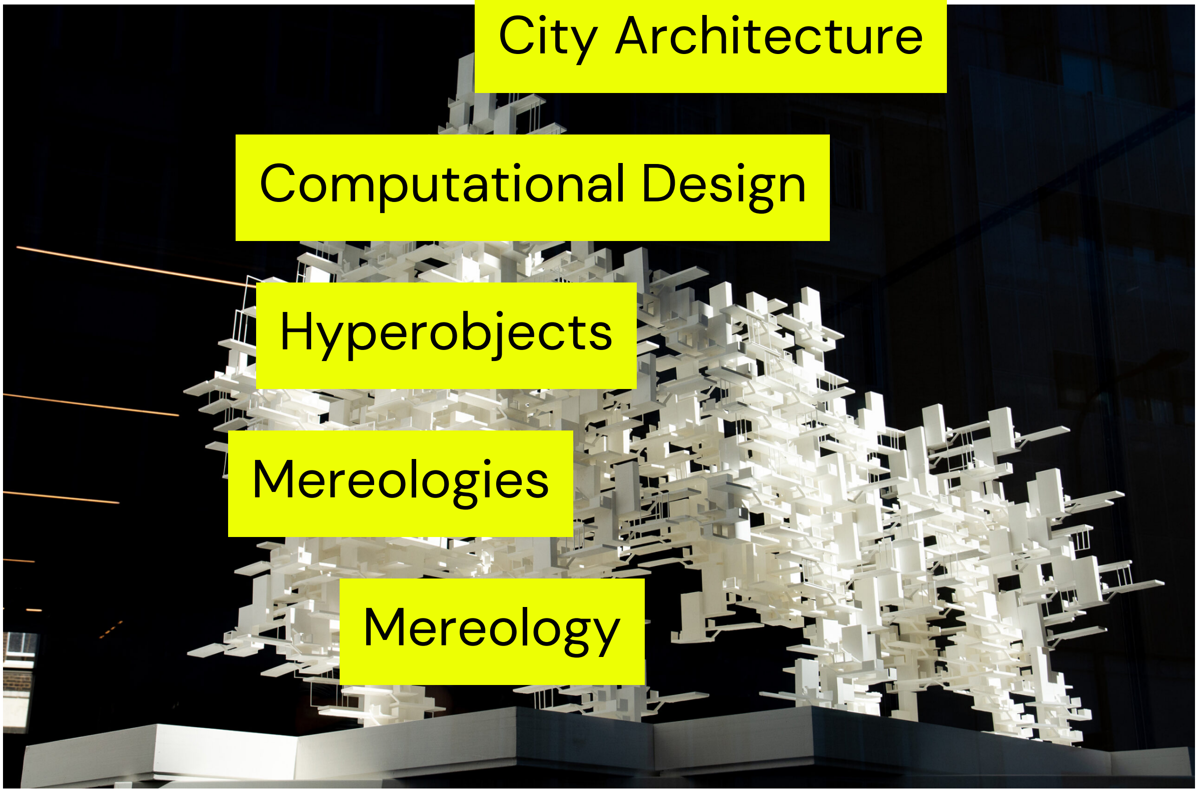
City Architecture

Computational Design

Hyperobjects

Mereologies

Mereology



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Object-oriented programming in blockchain has been a catalyst for philosophical research on the way blocks and their nesting are perceived. While attempting a deeper investigation on the composition of blocks, as well as the environment that they are able to create, concepts like Jakob von Uexkull's "Umwelt"[1] and Timothy Morton's "Hyperobject"[2] can be synthesised into a new term; the "Hyperumwelt". The Hyperumwelt is an object that is capable of creating its own environment. By upscaling this definition of the Hyperumwelt, this essay describes objects with unique and strong compositional characteristics that act as closed black boxes and are able to create large scale effects through their distribution. Hyperobjects are able to create their own Umwelt, however when they are nested and chained in big aggregations, the result is a new and unexpected environment: the Hyperumwelt.

In his book *Umwelt und die Innenwelt der Tiere* (1921) Uexkull introduced the notion of subjective environments. With the term "Umwelt" Uexkull defined a new perspective for the contextualisation of experiences, where each individual organism perceives surrounding elements with their senses and reinterprets them into its own "Umwelt", producing different results.[3] An Umwelt requires two components: an individual and its abstracted perception of its surroundings. Based on this process and parameters, notions of parthood and wholeness in spatial environments, and the relations that they produce with interacting elements, become relevant.

Space as a Social Construction

For Bill Hillier and Julienne Hanson these two parameters related to society and space, writing that "society can only have lawful relations to space if society already possesses its own intrinsic spatial dimension; and likewise space can only be lawfully related to society if it can carry those social dimensions in its very form."[4] What Hillier and Hanson argue is that the relation between the formation of society and the space is created by the interaction between differing social environments. Hillier and Hanson essentially make use of a mereological definition of the environment that states that parts are independent of their whole, the way that society is independent from its space, but at the same time societies contain definitions of space. Space is therefore a deeply social construction.

As Hillier and Hanson outline, our understandings of space are revealed in the relations between “social structure” and “spatial structure”, or how society and space are shaped under the influence of each other. Space is a field of communication. Within a network of continuously exchanged information, space can be altered as it interacts with the people in it.[5] However, this approach can only produce limited results as it creates environments shaped by only two parameters, humans and space. At this point is where Hillier and Hanson’s theory fails, as this way of understanding the environment relies only on additive information produced by interactions. If we were to expand this theory into the kind of autonomous learning mechanism that is mandatory for processing today’s computational complexity, we would end up with a slow, repetitive operation between these two components.

Hyperobjects to Hyperumwelt

Another perspective that is elusive from Hillier and Hanson’s understanding of the environment is how social behaviour is shaped by spatial parameters. Timothy Morton’s object-oriented ontological theory contradicts this anthropocentric understanding of the world. In *The Ecological Thought* (2010) Morton presents the idea that not only do we produce the environment but we are also a product of it. This means that the creation of things is not solely a human act non-human objects cannot partake in, but rather an inherent feature of any existing object.[6] For Morton, complexity is not only a component of society and space, but extends complexity to an environment that has objects as its centre and thus cannot be completely understood. He calls these entities ‘Hyperobjects”.[7]

While Morton uses the term Hyperobject to describe objects, either tangible or intangible, that are “massively distributed in time and space as to transcend spatiotemporal specificity”.[8] The term can be reinterpreted to describe an environment, rather than an object, which is neither understandable nor manageable. This environment – a Hyperumwelt – is the environment constructed by Hyperobjects. A Hyperumwelt is beyond comprehension due to its complexity.

Figure 1 – Qualities of the Hyperumwelt forming at the urban scale, Blockerties, 2018. Image: Junyi Bai, Anna Galika, Qiuru Pu, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2018.

The term Hyperobject is insufficient as it retains its own wholeness. This means that all components inside a Hyperobject cannot be seen (as it acts like a black box of information) but can only be estimated. Morton described the Hyperobject as a whole without edges. This stems from Morton's point of perception, as he puts himself inside of the object.[9] This position makes him unable to see its wholeness and thus it leaves him adrift of its impact, unable to grasp control of it. Here, also, the discussion opens about authorship inside the environments and what Morton suggests is that Hyperobjects have their own authority and there is nothing that can alter them or specify their impact on the environment.[10]

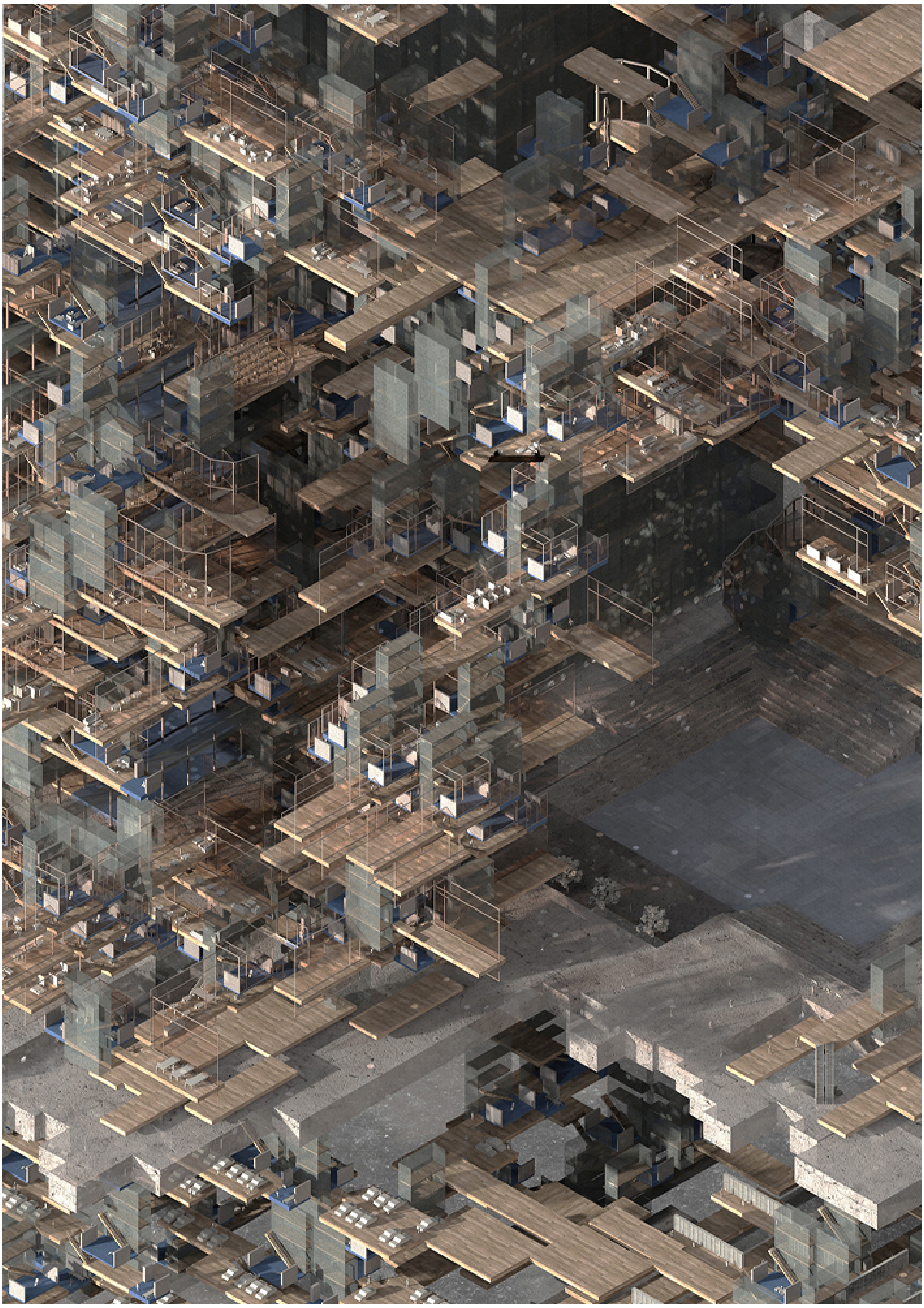


Figure 2 – Elements creating distributed patterns of information, creating their own environment, Blockerties, 2018. Image: Junyi Bai, Anna Galika, Qiuru Pu, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2018.

A Tree in a Forest

Yet there is also no need for the Hyperobjects to be clearly understandable. In terms of the Hyperumwelt, Hyperobjects can remain vast and uncomprehended. What is now needed are the implications of distributing nested Hyperobjects, seen as black boxes, inside an environment. An Umwelt is an environment constantly altered by the perceived information. This makes the Hyperumwelt a whole with porous edges that allows the distribution, and the addition or subtraction, of information. Another difference is the external position that the Hyperumwelt is perceived from, meaning that there is no need for it to be part of the environment. Since what is important is the distribution of the objects within the Hyperumwelt, a distant point of view is needed in order to detect the patterning of the distributed objects. While it will remain difficult to decipher and discretise the components, the patterns that are created can be seen.

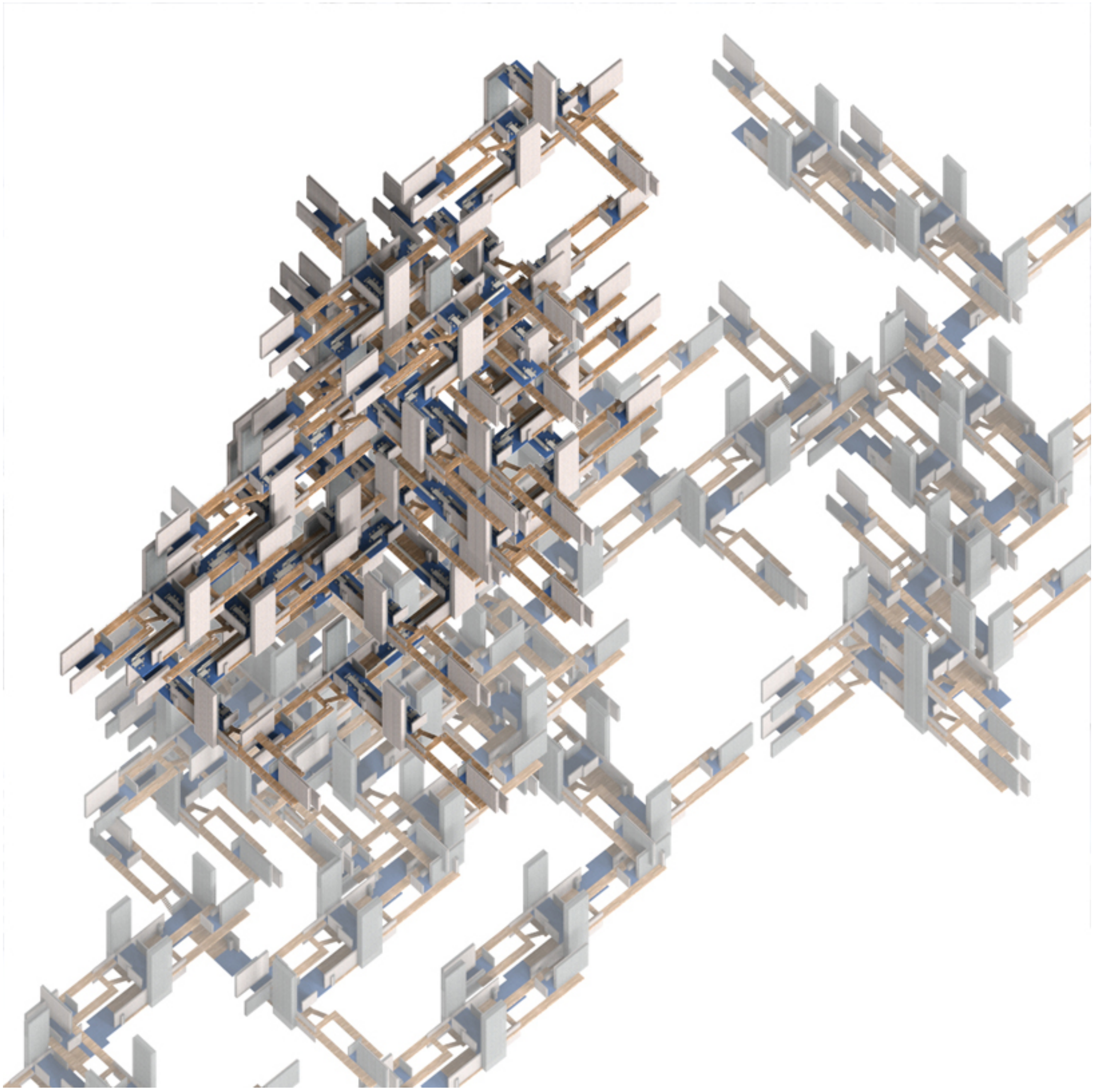


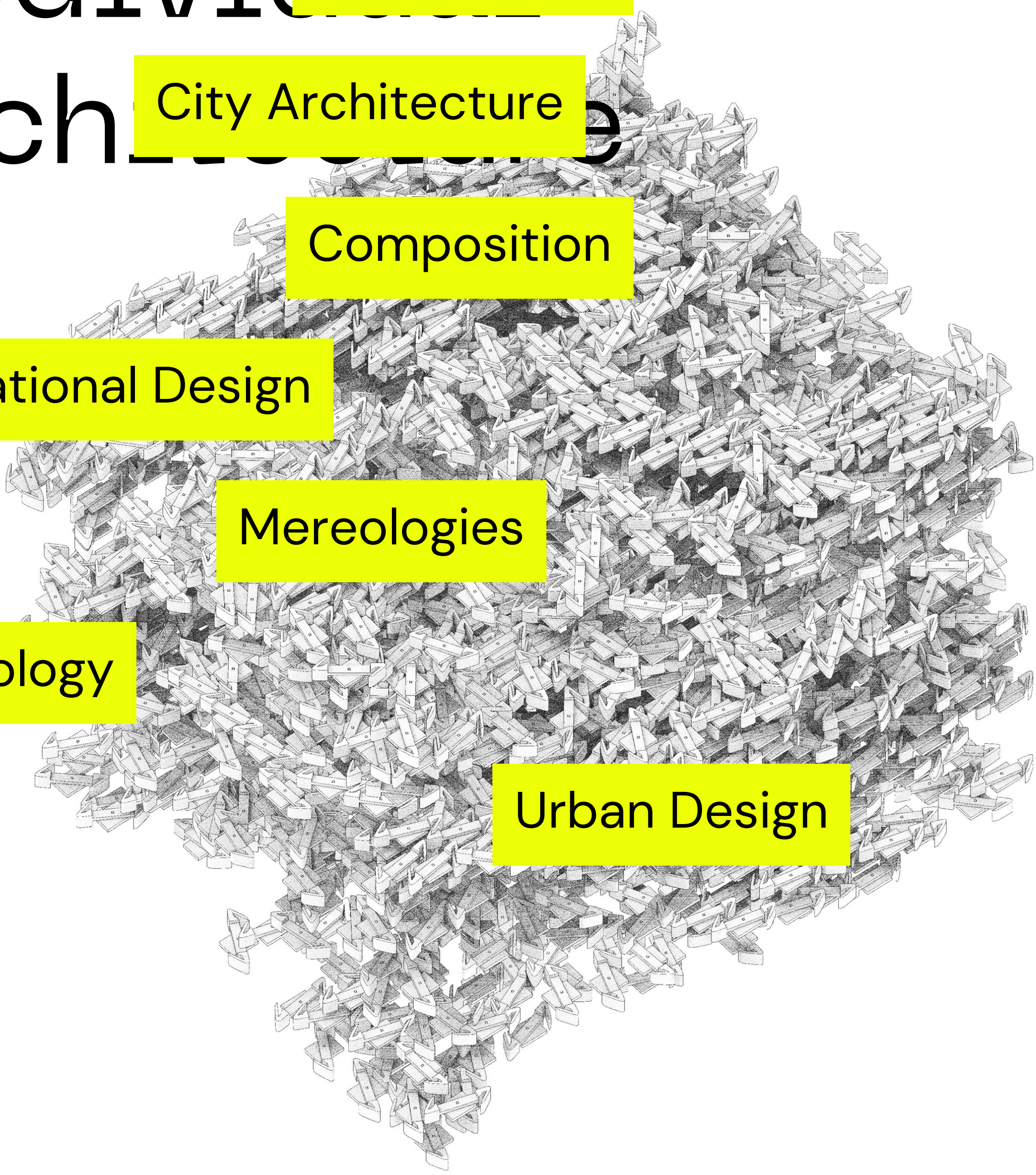
Figure 03 – Zooming in on patterns to recognise familiar qualities that provide a better understanding of the composed whole, Blockerties, 2018. Image: Junyi Bai, Anna Galika, Qiuru Pu, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2018, photograph by Rasa Navasaityte.

While the Hyperobject is a closed whole of parts that cannot be altered, a Hyperumwelt is an open whole of wholes that uses objects as its parts. So, while the Hyperobject gives us no authority over its consequences, the Hyperumwelt bypasses this in order for its wholeness to be controlled. Yet what is important for the Hyperumwelt is not the impact of one object, but the impact of multiple objects within the environment. This synthesis and merging of objects and their relations produces a new reality which may or may not be close to the reality of the single objects. A Hyperobject is looking at a black box – say, a tree – and knowing there is a pattern – such as a forest – and a Hyperumwelt is looking at the tree and knowing the impact that it has on the forest and the impact that the forest creates in the environment.

Figure 4 – Application of the Hyperumwelt concept in an urban proposal, Blockerties, 2018. Image: Junyi Bai, Anna Galika, Qiuru Pu, RC17, MArch Urban Design, The Bartlett School of Architecture, UCL, 2018, photograph by Rasa Navasaitytе.

Article 14 : Architectural Computation Within Codividual Architecture

Architecture
City Architecture
Composition
Computational Design
Mereologies
Mereology
Urban Design



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The design research presented here aims to develop a design methodology that can compute an architecture that participates within the new digital economy. As technology advances, the world needs to quickly adapt to each new advancement. Since the turn of the last century, technology has integrated itself within our everyday lives and deeply impacted the way in which we live. This relationship has been defined by TM Tsai et al. as “Online to Offline” or “O2O” for short.[1] What O2O means is defining virtually while executing physically, such as platform-based companies like Uber, AirBnb, and Groupon do. O2O allows for impact or disruption of the physical world to be made within the digital world. This has significantly affected economies around the world.

Paul Mason outlined in *Post Capitalism: A Guide to our Future* (2015) that developments in technology and the rise of the internet have created a decline in capitalism, which is being replaced by a new socio-economic system called “Post Capitalism”. As Mason describes,“technologies we’ve created are not compatible with capitalism […] once capitalism can no longer adapt to technological change”.[2] Traditional capitalism is being replaced by the digital economy, changing the way products are produced, sold and purchased. There is a new type of good which can be bought or sold: the digital product. Digital products can be copied, downloaded and moved an infinite number of times. Mason states that it is almost impossible to produce a digital product through a capitalist economy due to the nature of the digital product. An example he uses is a program or software that can be changed throughout time and copied with little to no cost.[3] The original producer of the product cannot regain their cost as one can with a physical good, leading to traditional manufacturers losing income from digital products. With the increase in digital products, the economy must be adapted.

In *The Second Digital Turn* (2017) Mario Carpo describes this phenomenon, stating that digital technologies are creating a new economy where production and transactions are done entirely algorithmically, and as a result are no longer time-consuming, labour intensive or costly. This leads to an economy which is constantly changing and adapting to the current status of the context in which it is in. Carpo describes the benefits of the digital economy as the following:

"[...] it would appear that digital tools may help us to recreate some degree of the organic, spontaneous adaptivity that allowed traditional societies to function, albeit messily by our standards, before the rise of modern task specialisation."[4]

Computational Machines

It is useful to look at the work of Kurt Gödel and his theorems for mathematical logic, which are the basis for computational logic. In his first theorem the term "axioms" is presented, which are true statements that can be proven as true. The theorem states that "If axioms do not contradict each other and are 'listable' some statements are true but cannot be proved."[5] This means that any system based on mathematical statements, axioms, cannot prove everything unless additional axioms are added to the list. From this Gödel describes his second theorem, "A system of axioms cannot show its inconsistency."[6] To relate this to programming, axioms can be seen as similar to code, yet everything cannot be proven from a single system of code.

Allen Turing's work on computable numbers is a result of these two theorems by Gödel. Turing was designing a rigorous notion of effective computability based on the "Turing Machine". The Turing Machine was to process any given information based on a set of rules, or a programme the machine follows, provided by the user for a specified intention. The machine is fed with an infinitely long tape, divided into squares, which contains a sequence of information. The machine would "scan" a symbol, "read" the given rules, "write" an output symbol, and then move to the next symbol. As Turning described, the "read" process refers back to the rule set provided: the machine would look through the rules, find the scanned symbol, then proceed to follow the instructions of the scanned symbol. The machine then writes a new symbol and moves to a new location, repeating the process over and over until it is told to by the ruleset to halt or stop the procedure and deliver an output.[7] Turing's theories laid down the foundation for the idea of a programmable machine able to interpret given information based on a given programme.

When applying computational thinking to architecture, it becomes evident that a problem based in the physical requires a type of physical computation. By examining the work of John von Neumann in comparison with Lionel Sharples Penrose the difference between the idea of a physical computational machine and a traditional automata computation can be explored. In Arthur W. Burks's essay 'Von Neumann's Self-Reproducing Automata' (1969) he describes von Neumann's idea of automata, or the way in which computers think and the logic to how they process data. Von Neumann developed simple computer automata that functioned on simple switches of "and", "or", and "not", in order to explore how automata can be created that are similar to natural automata, like cells and a cellular nervous system, making the process highly organic and with it the ability to compute using physical elements and physical data. Von Neumann theorised of a kinetic computational machine that would contain more elements than the standard automata, functioning in a simulated environment. As Burks describes, the elements are "floating on the surface, [...] moving back and forth in random motion, after the manner of molecules of a gas."[8] As Burks states, von Neumann utilised this for "the control, organisational, programming, and logical aspects of both man-made automata [...] and natural systems."[9]

However this poses issues around difficulty of control, as the set of rules are simple but incomplete. To address this von Neumann experimented with the idea of cellular automata. Within cellular automata he constructs a series of grids that act as a framework for events to take place, or a finite list of states in which the cell can be. Each cell's state has a relation to its neighbours. As states change in each cell, this affects the states of each cell's neighbour.[10] This form of automata constructs itself entirely on a gridded and highly strict logical system.

Von Neumann's concept for kinetic computation was modelled on experiments done by Lionel Sharples Penrose in 1957. Penrose experimented with the intention of understanding how DNA and cells self-replicate. He built physical machines that connected using hooks, slots and notches. Once connected the machines would act as a single entity, moving together forming more connections and creating a larger whole. Penrose experimented with multiple types of designs for these machines. He began with creating a single shape from wood, with notches at both ends and an angled base, allowing the object to rock on each side. He placed these objects along a rail, and by moving the rail forwards and backwards the objects interacted, and, at certain moments, connected. He designed another object with two identical hooks facing in opposite directions on a hinge. As one object would move into another, the hook would move up and interlock with a notch in the other element. This also allowed for the objects to be separated. If three of these objects were joined, and a fourth interlocked at the end, the objects would split into two equal parts. This enabled Penrose to create a machine which would self-assemble, then when it was too large, it would divide, replicating the behaviours of cellular mitosis.[11] These early physical computing machines would operate entirely on kinetic behaviour, encoding behaviours within the design of the machine itself, transmitting data physically.

Experimenting with Penrose: Physical Computation

The images included here are of design research into taking Penrose objects into a physics engine and testing them at a larger scale. By modifying the elements to work within multiple dimensions, certain patterns and groupings can be achieved which were not accessible to Penrose. Small changes to an element, as well as other elements in the field, affect each other in terms of how they connect and form different types of clusters.

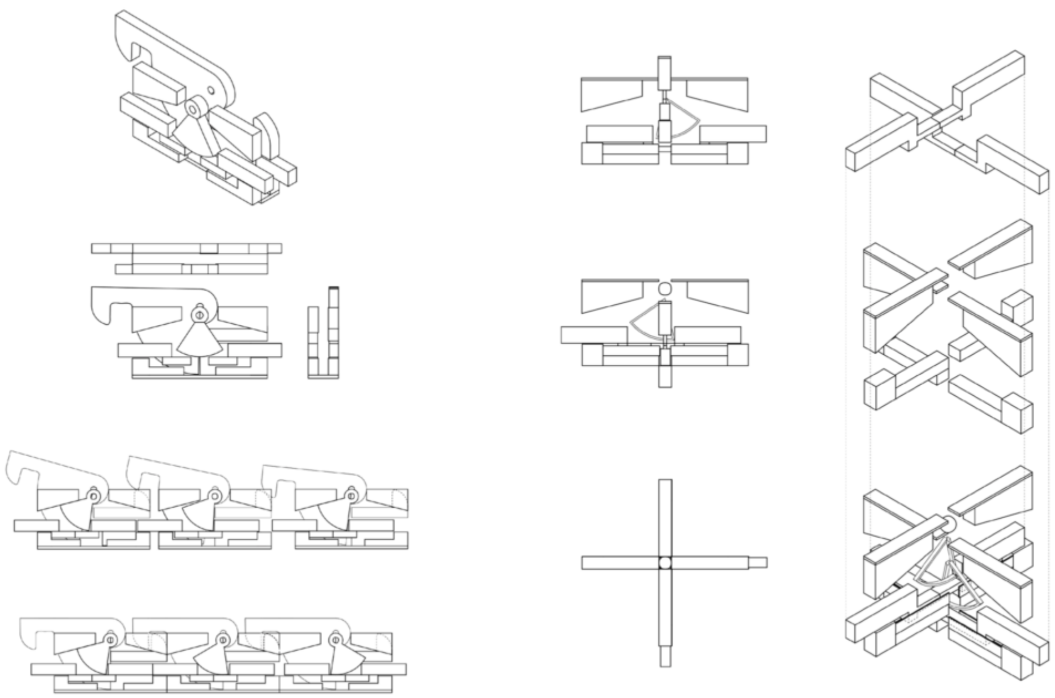

Figure 1 – Modified Penrose object simulation testing how individual objects interact and join together, forming patterns and

connections through fusion. Image: Anthony Alvidrez, Large City Architecture, RC17, The Bartlett School of Architecture, UCL, 2018.

In Figure X, there is a spiralling hook. Within the simulations the element can grow in size, occupying more area. It is also given a positive or negative rotation. The size of the growth represents larger architectural elements, and thus takes more of the given space within the field. This leads to a higher density of elements clustering. The rotation of the spin provides control over what particular elements will hook together. Positive and positive rotations will hook, as well as negative and negative ones, but opposite spins will repeal each other as they spin.

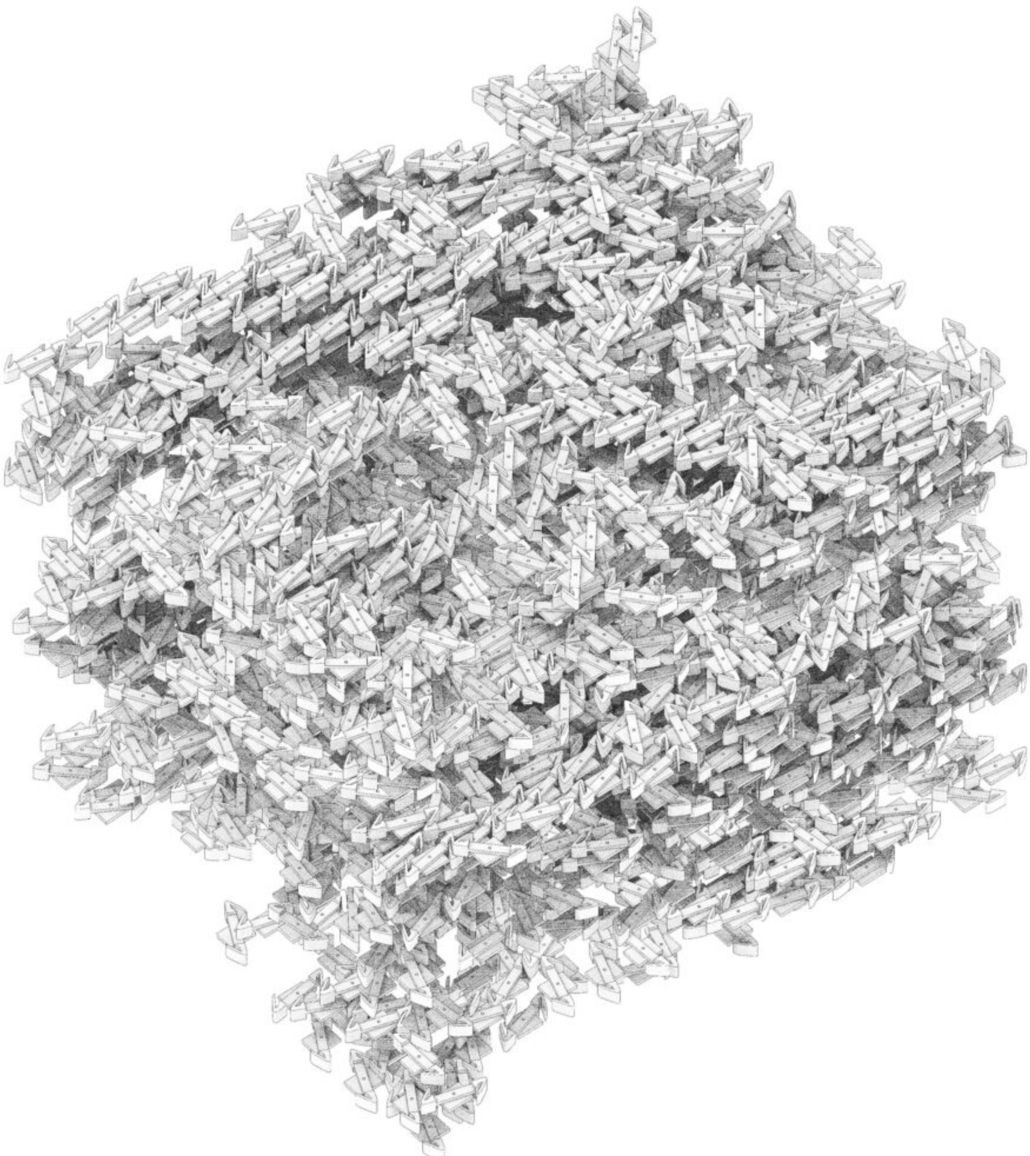

Figure 2 – Penrose block simulation allowing objects to interact with on a large scale and within three dimensions, forming a single whole object. Image: Anthony Alvidrez, Large City Architecture,

RC17, The Bartlett School of Architecture, UCL, 2018.

Through testing different scenarios, formations begin to emerge, continuously adapting as each object is moving. At a larger scale, how the elements will interact with each other can be planned for spatially. In larger simulations certain groupings can be combined together to create larger formations of elements connected through strings of hooked elements. This experimentation leads towards a new form of architecture referred to as "codividual architecture", or a computable architectural space created using the interaction and continuous adaptation of spatial elements. The computation of space occurs when individual spaces fuse together, therefore becoming one new space indistinguishable from the original parts. This process continues, allowing codividual architecture of constant change and adaptability.

Codividual Automata

Codividual spaces can be further supported by utilising machine learning, which computes parts at the moment they fuse with other parts, the connection of spaces, the spaces that change, and how parts act as a single element once fused together. This leads to almost scaleless spatial types of infinite variations. Architectural elements move in a given field and through encoded functions – connect, move, change and fuse. In contrast to what von Neumann was proposing, where the elements move randomly similar to gaseous molecules, these elements can move and join based on an encoded set of rules.

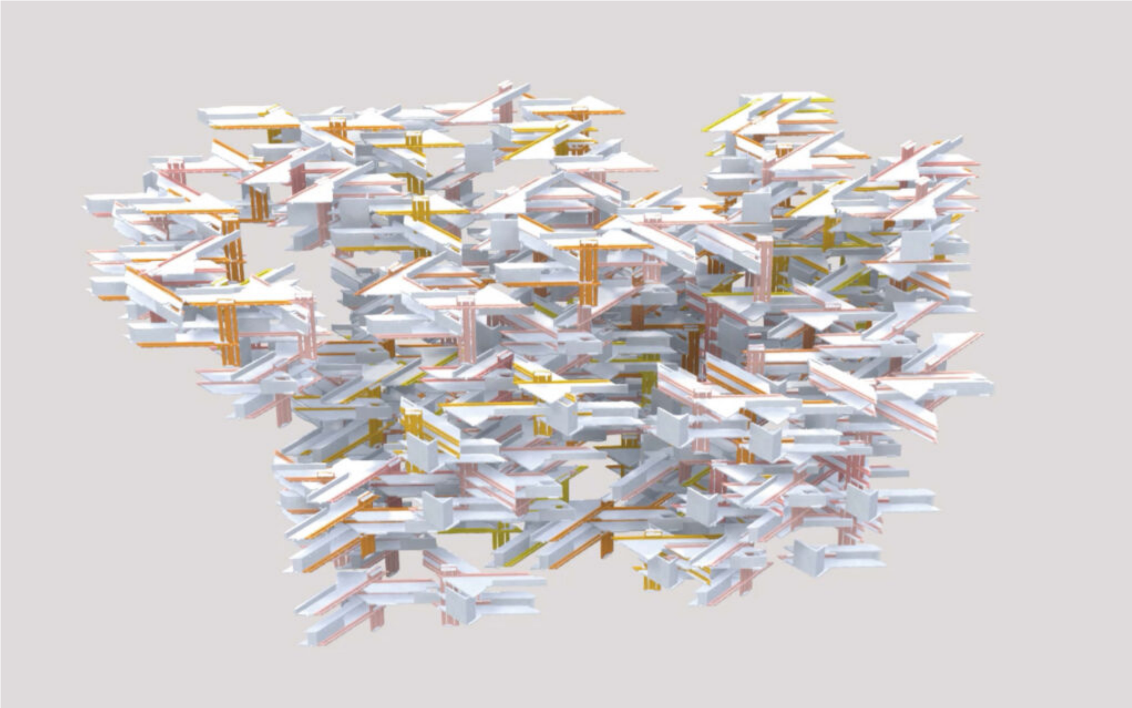

Figure 3 – Codividual architecture using machine learning. Image: COMATA, Anthony Alvidrez, Hazel Huang, and Shivang Bansal, Large City Architecture, RC17, The Bartlett School of Architecture, UCL, 2019.

Within this type of system that merges together principles of von Neumann's automata with codividuality, traditional automata and state machines can be radically rethought by giving architectural elements the capacity for decision making by using machine learning. The elements follow a set of given instructions but also have additional knowledge allowing them to assess the environment in which they are placed. Early experiments, shown here in images of the thesis project COMATA, consisted of orthogonal elements that varied in scale, creating larger programmatic spaces that were designed to create overlaps, and interlock, with the movement of the element. The design allowed for the elements to create a higher density of clustering when they would interlock in comparison to a linear, end-to-end connection.

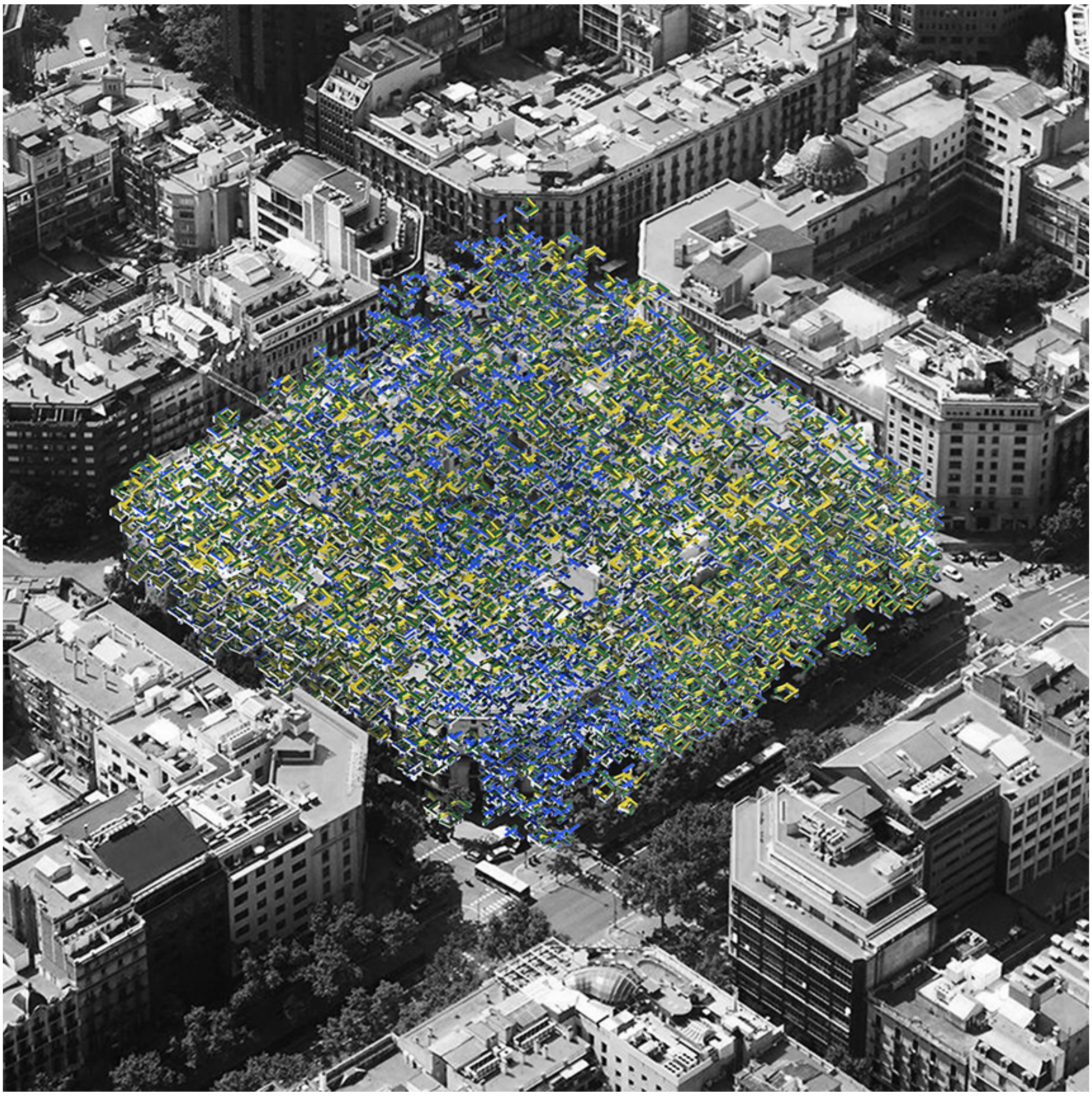

Figure 4 – Barcelona super block simulation. Image: COMATA, Anthony Alvidrez, Anthony Alvidrez, Hazel Huang, and Shivang Bansal, Large City Architecture, RC17, The Bartlett School of Architecture, UCL, 2019.

This approach offers a design methodology which takes into consideration not only the internal programme, structure and navigation of elements, but the environmental factors of where they are placed. Scale is undefined and unbounded: each part can be added to create new parts, with each new part created as the scale grows. Systems adapt to the contexts in they are placed, creating a continuous changing of space, allowing for an understanding of the digital economics of space in real time.

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