PROCEEDINGS

Estonian Academy of Arts
Faculty of Architecture

SPACE AND DIGITAL REALITY: IDEAS, REPRESENTATIONS/ APPLICATIONS AND FABRICATION

10/2020

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CONFERENCE: SPACE AND DIGITAL REALITY

IDEAS, REPRESENTATIONS/ APPLICATIONS AND FABRICATION

11 September 2019
Estonian Academy of Arts

Programme

8:45 Registration and coffee

9:00 Opening addresses

9:30 Keynote: Mario Carpo — The rise of computational brutalism

10:15 Questions and coffee

10:30 Gilles Retsin — The case for a fully automated timber architecture

10:45 Siim Tuksam — Modulated modularity: From mass customisation to custom mass production

11:00 Dagmar Rainhardt — Robotic braille: Combining tactile and visual narratives

11:15 Sille Pihlak — Protocolling prototypes / prototyping protocols

12:00 Lunch

12:45 Keynote: Roland Snooks — Strange behaviour

1:45 Roemer van Toorn — The new normal: A goodbye to language

2:00 Annarita Papeschi — Transindividual urbanism: Novel territories of participatory practices

2:15 Adria Carbonell — The solid matter(s) of digital nature

2:30 Wolfgang Schwarzmann — How does new technology provided by industry 4.0 change the job of a carpenter?

2:45 Questions and coffee

3:00 Keynote: Antoine Picon — Atoms and bits: Taking their hybridisation seriously

3:45 Keynote panel and discussion

4:55 End of conference

This conference was part of the Tallinn Architecture Biennale TAB 2019 programme

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FOREWORD

The journal in your hand is a new scientific publication of *Proceedings* by the Estonian Academy of Arts (EKA), Faculty of Architecture. With our other journal *Ehituskunst* and the series of translations, we have a tripartite research engine, each talking with their own voice about architecture and place creation, using their own format and linguistic style – they are worth a glance to explore the vocabulary and the changes to it and also to see what is boiling and brewing around this cauldron. It is also worth noticing what spices are used and how the content is stirred so it will not burn.

To be more honest and precise, the idea for this publication is a remembered concept from previous times – reusing is a highly topical issue. It is noteworthy to move and air the old shelves of our library and archives. When moving from our old rooms in Pikk Street to the new art academy building, one could not but notice old prints with the name *Proceedings* on its cover. Still we can witness the power of a book as an object in space. Holding the copy of an old edition suddenly explodes its might and influence, which by itself brings forward ideas and speculations, capable of touching the flow of time.

When old series summarised and concluded in a classical way the deeds and doings of different years, then this publication has the ambition to frame the new annual events – academic conferences organised by the Faculty of Architecture at EKA.

Paradoxically the physical and tangible cover of the first journal is *Space and Digital Reality*, which was the theme of our first academic conference in September 2019. It was divided into three subthemes: *Ideas, Representations / Applications and Fabrication*. The conference took place in the new building of the EKA within the framework of the Tallinn Architecture Biennale, introducing a two-day symposium.

This new series of conferences aims to invite and collect thinkers, researchers and doctoral students of architecture, allowing them to meet on a plateau of themes and debates, which could touch us all more or less.

One might ask, where else would we discuss Digital Realty, if not in the periphery of Europe, in an adaptive, e-residency promoting small e-state with angel-investors levitating on top of dew-covered forests and picking spawning start-ups, like mushrooms on a rainy September day.

We could mention that the first academic conference was greatly inspired by the research thematic and seminar discussions of our own doctoral students, at the heart of which is the concept of digitality and its influence on the creation of space. It is not insignificant that this discussion has helped to promote and maintain the by now 15-year-old 3DLab led by Martin Melioranski. Out of which the new VRLab and PROTOLab have emerged in the new EKA building. All of these have an intertwined effect on space education at the EKA as well as on the themes of the conferences.

It is quite unbelievable to realise that professors of the most influential universities, who happen to be global keynote speakers on current themes in architecture have met and tutored our students. Harvard Travelstead Professor of the History of Architecture and Technology Antoine Picon is tutoring Siim Tuksam. Associate Professor Roland Snooks from the School of Architecture and Design at RMIT is supervisor for Sille Pihlak. Professor Mario Carpo, who is the Reyner Banham Professor of Architectural History and Theory at the Bartlett, University College London has been tutoring Claudia Pasquero – the first doctorate to be defended at the EKA practice-based doctoral school.

I would like to thank whole-heartedly Antoine, Roland and Mario, who were the key-note speakers at our conference, setting the all-important background for the conference as well as instigating inspiring discussions.

Thank you all, who sent their ideas and thoughts to the conference and shared these with listeners in the EKA auditorium. Special thanks go to the Head of the Doctoral School, Professor Jüri Soolep and the science and development coordinators Pille Epner and Kadi Karine, who made the themes Space and Digital Reality so highly visible – so real.

I wish you all inspiring reading

Professor Andres Ojari
Dean of the Faculty of Architecture, EKA

THE NEW AGE OF DIGITAL REALITY

Economically and culturally, the world has entered the era of the Third Technological Revolution. In some areas the Fourth is already believed to have established itself. These revolutions are based on the digital domain and rapid advances in computing algorithms as well as autonomous robotics. In 25 to 30 years it has totally changed information, communication, entertainment and surveillance technologies both in form as well as in content.

A totally new reality has emerged with its own sovereign substance, structure and will. It can be called Digital Reality. It consists of information and communication networks, complex hierarchies of computational algorithms and the meaning system of its projections on screen, sometimes simply called 'the content'. It is fuelled by formal and informal online users – visible through multiple public and personal screens, and dominated by digital production giants like Amazon, Alphabet, Google and Facebook. One can speculate that we have arrived at the collapse of the paradigm called Modernism and Post-Modernism. Artificial Intelligence has developed to the level where humans are no match for it in complex games like chess, go and now even poker. Very soon AI is expected to be better than humans in planning economic ventures and military actions. All these indications of the previous paradigm in the mode of disintegration do not show any signs of slowing down.

Within the Digital Reality, information can create, interpret, mutate and copy itself limitlessly. The process is instant – the networks of communication distribute it immediately to all the receivers online. It is increasingly difficult to keep the plenitude of information within the constraints of property rights, including intellectual property rights. The Digital Reality with its potential has shaken the political and public institutions of modern liberal democracies. The Digital Reality has already partly broken free of current legal systems. Some believe it threatens the traditional major concepts elaborated during the Modernist paradigm – *labour*, *market*, *value* and *price*.

With the emergence of the Digital Reality several new phenomena have emerged: First, the plenitude of information is quite different compared to the state of culture and economy that existed before the digital domain prevailed. The plenitude of information means infinite abundance usually in the form of images on screens. We might call this the *imagospheric condition* of our time.

Second, the digital platform has transformed documents, fiction, advertising and news to form a new unified field – infotainment, as it is sometimes called. The previous typology disappears or merges. To start with, the public and private divisions in politics, culture and space disappear resulting in a strong amalgamation of the *public and private*, but within it also reality and fiction. This has been recently described as the post-truth era of public media.

Third, the last Technological Revolution advanced the idea of the Internet of Things (IoT, Web of Things, Internet of Food etc.). This is based on the possibility of embedded digital devices and communication between physical objects. This has created a parallel digital universe, which gradually stops being parallel but becomes an integral part of material existence. Therefore, we are witnessing a strong hybridisation of material and digital.

Fourth, our biocular human vision and awareness of space allows us to sense the surrounding world in a stereoscopic way – we comprehend space. This is called *perspectiva naturalis* as compared to *perspectiva artificialis* – an analytical-geometrical construct to present or simulate the spatial qualities on a 2D surface. Today, due to digital possibilities, the difference

between natural vision and visible representations on a 2D surface are gradually disappearing. The amalgamations within the digital visual domain become more direct and closer to human experience. We are witnessing a strong hybridisation of informational and existential.

Fifth, the development of the neuro-sciences and digital bionics/prosthetics might lead in not so distant a future to the direct links between the digital and the conscious. The conscious can have direct links to the Digital Reality and vice versa.

The Digital Reality will have a major impact on architecture and space. What will happen to architectural education and practice in the context of the loosened paradigm of Modernism and the era of confusion brought forward by the Third Technological Revolution? What kinds of directions for development are available?

It seems that several fundamental elements of architectural design that have been taken for granted for quite a long time – nearly six hundred years – are changing now. Among them three are most obvious:

- the representational system of architectural design,
- the means of producing architecture designs, and
- the authorship of an architect designing.

The period when the current representational system, means of production and authorship in architecture were established was the Renaissance.

The representational system of architectural design is still fully used in the form of working drawings (projections in the form of plans, sections, elevations and 3D/perspective), which epistemologically constitute different sections of an ideal imagination of parallel vision in the Cartesian space, finally governed by coordinates and mathematically describable to the smallest detail. The current system of architectural representation is nevertheless rapidly changing in two directions: becoming an algorithm of the parametric solution or becoming a virtual reality, supported by BIM. The traditional working drawings on paper are becoming obsolete. Instead of a drawing, there will be algorithms ready for CAM, cutting or printing.

This change would not be significant unless we agree that in the design process it is the personal representational language, which, being in touch with the reality of matter and society, allows architecture to become a cultural and creative phenomenon.

The means of production in architectural design are still fully used in the form of traditional building techniques. Nevertheless, current new composite structures and materials are changing the work processes. Algorithmic design and BIM today already enable a fully automated flow of the materials and construction of the final product in CAM. Further development promises large-scale composite objects materialised through 3D printing or other additive technologies. Autonomous builder-robots are already in use.

The authorship of the architect as designer is still used in the form of intellectual property rights and in some countries through the protection of the architectural profession. Today, the system based on the intellectual rights of an author is undergoing change. The sectorial studies of ACE show that the role of an architect has diminished as the principal consultant. An architect is turning into one of many consultants. The position of the author in general is being questioned within the digital platform. The Digital Reality is introducing new methods of creation, and in some areas already rejecting the author entirely – within the parametric development of design and user participation, authorship is also being questioned from the

theoretical and legal point of view. As digital fabrication processes invite endless design variations, it is clear that some parameters will be chosen by someone other than the original author.

The representational system of architectural design that has now fully embraced the digital means of creating and describing architectural artefacts in the format of digital 3D objects and the projections of these, is also influenced by the new representational means of space itself. The digital platform has induced totally new and massive descriptions of the surrounding space for mobile devices as well as desktop computers.

We can note the eroding function of traditional spatial reality based on orthogonal and perspectival geometries. Cartography has always been an important epistemological as well as instrumental tool. With the development of Google Earth and Google Maps this has not changed: now the preferred projection is a tilted or axonometric surface. Very often the screen map hybrids into a 3D image, if that particular information is available for the space-stitching algorithms. We do not rely on orthogonal projection in guessing distances – we rely on a coordinate system of points or addresses. The necessary distances are produced in a digital numerical form. The seeing and knowing are separated into different planes on the map. The distances depending on the search are also modified by other data: permeability, density of traffic etc. The distances are not observable and quantifiable any more as space but as a relation within the algorithms of software, totally hidden from the observer.

Especially odd and distorted for a conservative eye is the space described in Google Earth, where depending on the angle of the satellites and the algorithms used, the aerial photographs exhibit reverse perspective and other spatial distortions. The street-view function also allows a "cubist vision" of represented space. Thus, reality becomes shielded from the observer by a totally new representational format. It can easily be tested when we move the observed object up and down the screen – its configuration and proportions change. The simple descriptive geometry has fully collapsed into a new dynamic and a fluid representation of space. It remains to be investigated and imagined what kind of epistemological shifts this new fluid perspective will impose on our understanding of space and images.

It is not only space that is shielded from the observer by the Digital Reality. Most of our work, even the simple tasks, requires the digital layer and is presented by a screen. At least more than 60% of the world population look at the screens of phones every day.

Ernest L. Boyer and Lee D. Mitgang suggested in their review of architectural education in the US, that the definitions in the accreditation of the architectural curriculum should be changed so that *fundamental knowledge, design, communication* and *practice* became newly interpreted as:

- "discovery of knowledge",
- "integration of knowledge",
- "sharing of knowledge" and
- "application of knowledge" (Boyer and Mitgang 1996).

Architectural education can thus be seen as the collection, revision, interpretation, transformation and creation of architectural knowledge. The recommendation of Boyer and Mitgang seems highly appropriate in its universal ability to describe the existence of any knowledge in the new circumstances of current developments of the recent Technological Revolutions. Digital Reality allows instant discovery, integration and sharing of any knowledge – thus, becoming an environment of designing knowledge. We design it by searching via digital screens and the

digital production giants design it by creating algorithms that present the knowledge. We just do not know what the goal of that design is.

Some parts of the Digital Reality are already so well organised and exact that they can be used as a design horizon for different purposes. Without the simulation capacity, innovative and efficient custom-made production cannot be realised. This promotes the belief that the equilibrium between private corporate interests and open knowledge networks somewhere exists. The imagospheric condition that has emerged with the Digital Reality and has rendered reality and imagination into a universal fake, adds another layer of complexity to all knowledge networks. It masks and colours the different forms of discovery, integration, sharing and applying of knowledge, but it also predicts the new forms of knowledge creation, where image and imagination will even have a substantially larger role than now.

During this conference we look forward to the *new age of digital reality* and ask – is it becoming the *new era of imagination*?

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Jüri Soolep
Head of PhD School, Faculty of Architecture,
Estonian Academy of Arts

ATOMS AND BITS: TAKING THEIR HYBRIDISATION SERIOUSLY

Antoine Picon
Harvard Graduate School of Design

Transcribed presentation from the conference: Space and Digital Reality, 11 September 2019, Tallinn

The spatial turn of digital culture

When the digital initially developed, something troubling emerged: the notion that the digital world was somewhat analogous to a space in the physical sense. If you think a little bit, there is no reason for why we began almost immediately to compare the electronic world to actual space. This can be traced back as far as the first representations of what was to become the internet in cyberpunk literature – think of authors like William Gibson or Neal Stephenson. Very often it appeared as similar to a gleaming, scintillating Las Vegas-like space. This spatial character was further reinforced when William Mitchell in his mid-1990s book *City of Bits* exhorted architects to become the designers of the virtual world. What is striking is that for a while the electronic space was seen as reassuringly separate from the physical space. William Mitchell is once again emblematic with his insistent suggestion made to designers to go from bricks to atoms. It created at the time quite a polemic with Kenneth Frampton, who saw in this position the risk of a dramatic dematerialisation of the architectural discipline. His opposition was among the reasons that led him to research and publish on architecture and tectonics.

Video games also reflected this state of affairs. Indeed, they were conceived as spaces, but spaces distinct from physical reality, spaces having often a fantastic quality. Hence, the recurring accusation made against them that they constituted a dangerous and addictive diversion from the real world.

The past decade has seen a kind of complete break from this conception. In many cases the physical and the digital are not separated but on the contrary intimately linked. Their connection will be the subject of my talk. Taking seriously the term "reality" invoked by the organisers of this conference, I would like to ask what is the reality that we live in today?

Electronic content cannot simply be considered as a kind of fourth dimension perpendicular to the other three, like time. For there is an imbrication of the physical and the digital, which has led very often to the use of notions such as augmented reality. Again, the difference with the relationship between space and time is quite noticeable. Time does not augment space; it develops in another direction, even if we have known since Einstein that the relationship between space and time is actually far more complex.

Of course, all the electronic contents are not impacted, but so many of them are that one can speak of a kind of "spatial turn" of the digital, to transpose the late urban geographer Edward Soja's famous expression. Two phenomena have played a role in this evolution and I am going to start with them. They are so evident that we usually do not pay much attention to them. I find them all the more fascinating since we do not pay them enough attention despite their importance.

The first is geolocation, a consequence of GPS. It is still fairly recent, but it has become almost invisible. The blue dot on our smartphone screens seems absolutely self-evident. How not to think of the remark made

by the Silicon Valley guru Mark Weiser in 1991 in his famous article 'The Computer for the 21st Century', I quote: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they're undistinguishable from it?" We have become totally accustomed to geolocation as if it was an absolutely natural thing that has always been with us. Another way to think of that would be to say that the GPS is actually the true infrastructure of a contemporary digitally augmented world.

Infrastructures are precisely technological systems that disappear, and Benjamin Bratton is often close to this intuition in his attempt to theorise the layered reality, which merges atoms and bits through the notion of "stack."

As a historian, geolocation appears to be truly revolutionary. Very often fundamental shifts that we attribute to the digital are actually about geolocation. We are probably the first civilisation to know, often in real time, where billions of objects and people are. One of the great effects of the telecommunication revolution was, from the start, being able to know where people and things were.

For example, the railway revolution was a true revolution because of the telegraph, which allowed us to know where the trains were. Today, we are observing something at a much larger scale. Many of the platforms that have transformed our everyday life, beginning with Uber, would not be possible without geolocation. Geolocated and connected objects are transforming reality fundamentally and they are, again, most of the time invisible. We do not perceive them as such, except on sites like those who map month after month, the spread of connected objects on the planet. They are pretty much beginning to cover the entire planet. Geolocation was the first of my two phenomena.

The second phenomenon, which has been mentioned also before (GPS and geolocation have provided the infrastructure, the true engine of this evolution, of the kind of hybridisation of atoms and bits) has to do with the rising consciousness that cities play a determining role in the evolution of our world. Who has not heard the almost ritual statement: "in 2050, 68%, it varies usually between 65% and 75%, of the world population will be living in cities."

We live for sure in an urbanised world, despite the critique of theorists like my colleague Neil Brenner, who prefers to evoke a phenomenon of planetary urbanisation following the French Marxist urban sociologist Henri Lefebvre.

This statement is typical of the new importance of cities. What is also typical is the success of books like Harvard economist Edward Glaeser's *Triumph Over the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier and Happier* — I really like the title by the way! Only an American could come up with such a title. It is quite revealing. Leaving aside the ideology because there is of course a ton of ideology behind this kind of

statement, two things are sure: cities have been instrumental in globalisation and they are the greatest producers of data. Big data is mostly urban data. And the success of Carlo Ratti's *SENSEable Lab* at MIT is linked to the fact that it was among the first research programmes to identify this phenomenon and to tap into the vast amount of information generated by cell phone location. Here is an image of the now historic *Realtime Rome* project in which the Lab tracked the movement of the public gathering for a concert of Madonna in Rome.

The smart city dynamics is actually a direct consequence of this. Most of the smart technologies we are talking about today are actually based on geolocation and are used to gather and exploit data.

Equally telling probably for me of this kind of conjunction is the revolution in urban mapping that is taking place before our very eyes. This something I have been working on for a while: how the new maps of the digital age are perhaps the most emblematic documents of the hybridisation between atoms and bits.

Speaking of urban mapping, the first thing to note is that what we call maps today is very different from what maps used to mean. The map today is in continuity with all sorts of other media; the map has also become indifferent to a number of traditional distinctions. For example, there is no clear difference today in many cases between mapping and monitoring, and the dream of the control room that very often accompanies the smart city movement completely merges the mapping and monitoring dimensions. This is actually a very new thing.

There is also a continuity today stronger than ever between mapping and simulation, to the point that one can never be entirely sure about the degree to which something is it based on the collection of existing data versus an extrapolation produced by models. Above all, the classic dichotomy between database and representation, which dominated cartography for a very long time, no longer applies. Is the map basically a database transformed into a picture or is it actually a view from somewhere? This dichotomy has become irrelevant.

As you, some of you, may remember, this is a dichotomy that emerged as early as the Renaissance through the opposition between Leon Battista Alberti and Leonardo da Vinci. While Alberti instead of providing a map of Rome gave a series of coordinates of remarkable points in the city of Rome, Leonardo as for him, suggested that the map was an image with his famous plan of the city of Imola.

Today we no longer recognise this partition line. Laura Kurgan has written about this shift. When we look at maps, what do we see? Do we see databases, do we see images? What appears on a map? Again, what we call a map today is very different from what it used to be. Contemporary maps are at the same time databases and collections of visualisations. They are all kinds of things. They tend to suggest something to which I will return at the end of this presentation, namely that the city is computable. I will return to the question of computation. What is striking at this stage is that if we try to define what is "the real" today we have to acknowledge that "the real" has become a mix of atoms and bits. But it does not seem to have impacted to the same degree architecture as it has urban planning.

It is striking how designers are, for example, relatively absent from the smart city movement. This movement has concerned mostly engineers, political scientists, economists, etc. In such a context, the question for me is: What should designers do? How can we take the hybridisation of atoms and bits really seriously beyond invoking it as a perfectly natural condition? I am going to argue that taking it seriously should actually lead architecture to rediscover its strong physical content.

Transformed design processes and professional structures

When I said that designers are relatively absent, let us not exaggerate. They are absent from the debates about the smart city, which is worrisome, but the hybridisation of atoms and bits is very present in design under other guises. For example, digital fabrication is clearly a process that is based on the hybridisation of atoms and bits and it really happens at the intersection of both worlds. And the notion of

material computation, which has been popularised by researchers like Achim Menges or Jenny Sabin, is typical of that – with the idea that there is no longer a kind of ontological distinction between matter and what is computable, which is actually a profound epistemological change.

It is thousands of years of culture that has been transformed. The example of digital fabrication enables us to go further in the understanding of this process of hybridisation. The first thing to note is that before hybridisation what actually happens at the beginning is a separation. And then a rejoining. Information is first separated from the process of fabrication. We have a lot of discourses and practices today that revolve around the inseparable character of matter and computation; material computation is one of them. Actually, what has happened initially is something like this: you take matter and information drastically apart and then you inject information into matter. We talk a lot, by the way, today about designers as a new kind of craftsmen and it is striking how Ruskin has become a pervasive reference in today's discourse. I have argued elsewhere that it is actually a formidable nostalgia that is expressing itself through this reference. In fact, we have never been so far away from Ruskin. And that is because we have completely taken apart matter and information.

Then what takes place, and this is where it is complicated, is a complex process of reassembling along many channels. Think of the diversity of algorithms and machines that enable this reassembling. The result is like a densely woven fabric. I am not a great fan of actor-network theory but I am actually going to use one of the metaphors which I quite like from Bruno Latour in *Reassembling the Social* in which basically he argues that there is no such thing as society as a stable entity. What there is is what he called the "thread of the social", that is to say the constant readjustment and reassembling of objects and actors, so that something that he calls "the social" comes into existence. Instead of thinking of augmented reality in the traditional sense of reality envisaged as something stable, we should rather think of it as something dynamic, as a process or a series of processes, not a static state of things. Just like urban maps, digital urban maps, do not depict a static reality; they picture phenomena that are happening and unfolding.

This might actually be one of the most disconcerting features of today's reality that it is no longer the immutable world architecture used to refer to. And you know architecture was admirable in conveying this idea of order, the order of things as Michel Foucault would have said. Not anymore: architecture is no longer in a completely stable world but in a moving one. Expressing this moving condition may be the reason why, before the digital discrete took over, we had so many of these (continuous) waves and baroque movements. Behind that of course we have the rise of information and of course the notion that everything might be made of information and hence submitted to computation. And you know material computation if we take it, there again, literally means that there is no material before it is computed in some way, which is ontologically a bit disturbing.

Of course, we know that architectural design was always driven by information and Carpo has shown that, after all, the five orders were like a code applied to matter. But I would argue that today this is reaching a new level of intensity, and this intensity radically alters the underlying conception of the world. It is no longer a static order that is revealed but a dynamic universe of operations. It is probably the biggest difference with the Baroque era, even if for a very long time there was a kind of analogy between blobs and other eventful digital forms and the Baroque.

The Baroque; in the Baroque era, architecture was indeed animated, and in that respect the world of Rene Descartes is fundamentally Baroque with its vortices; it is a complex assemblage of vortices, but reality was still based on fundamental, stable underlying principles. Today, reality is like a series of circulations and, to use again a Latourian metaphor that I quite like, it is analogous to a net thrown on something, the profound nature of which we ignore. And I would say that in some ways augmented reality is like the net that we throw onto the world to try to capture some of its features.

Until now I have stayed in the elegant realm of ideas, but I think there is a change as powerful going on in

the practice of architecture because in the end architecture is about building stuff. Something that we tend to forget in schools of architecture sometimes. The epistemological changes of architecture are all the more powerful usually because they are articulated with professional change.

A few words on some of these changes because they do happen. I am always struck by the amount of literature we have of all kinds of fancy ideas about the digital, and how little we say about the profession. And the profession is actually experiencing a very similar set of dislocations and reorganisations. Let me mention quickly a couple of things.

First, it is clear that traditional authorship, traditional structures are kind of exploding. All over the world you hear things about open source architecture and networked authorship. We can already see more collaborative, networked forms of authorship in other fields of design. Dutch fashion designer Iris van Herpen's Quaquaversal ready-to-wear collection centrepiece, with the help of Jolan van der Viel and Marjan Colletti, is typical of these new forms of collaborative authorship. This will be accentuated by cooperation with machines. What will it mean to be an author in this new context? In the case I just mentioned, shouldn't we consider as the author a collective composed of the fashion designer, the architect in charge of the robotically programmed arm plus a third guy who designed the elegant cloth that covers the robotic arms? Designers like Jose Sanchez in his Plethora Project have explored another alternative: what if it was also possible to associate the public at large with the design process in a truly open-ended perspective?

We have that kind of explosion of traditional structures, and at the same time a massive consolidation. Of course, we live in multi-author era but some are more authors than others, with a kind of winner-takes-all, as in the music industry. There is something going on, which evokes the disassembling and reassembling of the social or that which augmented reality is also about.

To take another example, I spoke of consolidation, one of the consequences of the internet and the digital has actually been the rising size of most of large architectural practices. That was a reasonably big practice in the 1950s and 1960s, I suppose you all know who that bespectacled guy is in the photo: Le Corbusier. See the contrast between Le Corbusier's and Zaha Hadid's practices. One is still counted in terms of individuals, the other in hundreds of designers. A 500-person practice is no longer seen as purely corporate. Once again, the structure of the profession is completely changing.

There is a kind of double process of disassembling-reassembling of different configurations in which you could also argue that probably the best way to describe the profession today is no longer using traditional structural metaphors but rather these kinds of threads of things that organise and produce what we call architecture.

Now what is striking, however, is that buildings are still buildings, and disappointingly, buildings. I have heard a lot today about how we are getting out of the modern etc., but most of the architects that make it, still build in brick, concrete, steel, you name it, and sometimes in relation to the good old-fashioned car that fascinated so many of the moderns. What about buildings, what about form and space, how could the hybridisation between atoms and bits impact the near future?

Towards a new materiality

I have some recurring obsessions especially with what I call materiality. The geometry of architecture has changed, we have seen the smooth, now we see the spiky, tomorrow we may observe something else, so for sure geometry has changed, forms have changed, but buildings are still extremely classical constructions, and I am sure that Gilles Retsin is dreaming of actually building one of his projects.

Should we look towards a true hybridisation of architectural space and information? But what does this mean in practice? Can we go, for example, beyond the multiplication of screens used for experiments like this all-digital media city a decade ago? Carlo Ratti, to mention him again, has tried to have this kind of Matrix-like ambiance in a pavilion in Saragossa but that was for an exhibition hall, definitely not for a living room.

Should we play the card of interactive spaces like, for example, the Mori Building Digital Art Museum in Tokyo?

How about the internet of objects? Connected objects will for sure change the practice of spaces, interior spaces, but to what extent is this an architectural question?

My answer to all that is probably to say that the question is perhaps not so much to extend architecture along these lines than to mobilise it to express the new reality of the digital age. What is fascinating with architecture is how archaic it is in some ways; even with robots I think architecture will remain a relatively archaic practice. The fact that we still refer ourselves, now and then, to the primitive hut in the digital age is telling.

How do we express what is going on, the disaggregation and reaggregation of reality that is taking place? I would argue this is not the first time that architecture is trying to express the fundamental features of the reality that surrounds it. Take modernist architecture. We have said a lot of terrible things about modernism but modernism was able to express the age of the car without becoming like a car. The Villa Savoye has no wheels but it has the capacity actually to propose a coherent reflection on what it means to live in a mechanised age. In a similar way, the fundamental problem of architecture today is to propose a coherent reflection on what it means to live in this strange state of altered or augmented reality that has been created by the digital.

Architecture must find ways to express the new reality of matter made both of atoms and bits of information, and this while relying mainly on atoms. And for me this is of course also related to an inquiry into what we call nature today. Emergence was mentioned by Roland Snooks, but what exactly is an architecture of the age of emergence is not a simple question. Above all, what is an architecture of the age of computable matter, which is fundamentally different from traditional matter? Of course, we know that digital fabrication is key in that respect, and we have seen a number of examples of that today. We also know, and I found it very interesting that Roland came to the question of ornament a number of times – or to be more accurate the dimension of the ornamental, certainly not ornament as we know it – that the ornamental is a key issue today, in relation very often to fabrication.

Let me indulge in one of my favourite themes, which is to stress that materiality is actually not a fixed thing. Not to deny that there are natural bases to materiality. Its solidity among them. But I argue that part of what we call materiality involves our relationship with the physical world, a relationship which is partly determined by culture. I often give the example of ghosts. In the 19th century, ghosts were for a lot of people much more material than they are today, since you could measure the spiritual aura of ghosts and there were even photographers of ghosts. So many people believed that you could take photographs of ghosts, that they were more material than today.

Someone this morning talked about touch. To make myself clearer I wanted to go back to an 18th century philosopher Étienne Bonnot de Condillac and his *Traité des sensations* (*Treatise on the Sensations*) (1754) in which he imagined some statue who has the possibility to become a subject but simply has no senses and no self-awareness. Condillac imagined giving the statue successively sight, hearing etc. The most determining moment is actually not vision; it is touch. Why touch? Because when you touch something you realise there is an external world that resists you and because of this resistance you realise that you are someone in the world.

So strangely it resonates with what neuroscientists like Antonio Damasio today remind us of when they evoke embodied knowledge: in order to become truly ourselves we need to be immersed in a physical world through the mediation of the body. My point would be to say that when architecture works on how to express this material world, it actually works on this double question: what is the world out there, but also who are we as people who experience this world? For me the central question raised by digital reality, by augmented reality, is about who we are.

One can speak of a kind of co-construction or simultaneous emergence of subjectivity and the physical

world. Many architects have written about that. For example, Tadao Ando seems to echo Condillac when he explains that architecture is actually about the simultaneous discovery of material, form, light, things which are out there, and who we are. The "I" which corresponds to one's body, is in his opinion inseparable from the perception of space and materials, a process that he calls the shintai and that could be easily related to what it means to truly inhabit a place, or to dwell as Martin Heidegger would have put it. For Ando, the shintai constitutes the true foundation of architecture, what makes it both possible and desirable.

I think that we sometimes tend to forget that the question of for whom is architecture meant is as important as what should architecture be, and is inseparable from it. Designing architecture is, of course, trying to find new form, style, whatever, but it is also about asking oneself for whom am I building.

The post-human becomes unavoidable at this stage. There has been a plethora of suggestions about how different we have become in this new world than before, Gregory Bateson was quoted by a number of people, but before discussing some of the issues associated with his work, it is important to insist again on the connection with the question of inhabiting. You find that in Heidegger's seminal writing on that question, inhabiting is about relating to a world out there and simultaneously becoming yourself by relating to it. And I think this is what architecture proposes: to experience the physical world in such a way that it suggests things about who you are. And dwelling, inhabiting; this is what it is about for me.

So, who are we? We for sure know that we are probably very different from our predecessors. I am not a post-human fan, actually post-human is the latest in a series of hypotheses about what it means to be human, but clearly, the cyborg has been a possible identity. Also, something that has been mentioned that Bateson and others and that William Mitchell later has tried to theorise in the architectural realm: how can we both inhabit in our body and partly outside our body? With this interrogation come all sorts of issues of distributed subjectivity etc. How can we design from such a perspective? That is where it becomes really complicated, how can we design for people evidently with bodies but also living partly out of their bodies?

Another Japanese guy, Toyo Ito, famously declared in *Tarzans in the Media Forest* that we must now design for people who are both within their body of flesh and have an electronic body of some sort. The latest version when one follows this thread is the notion of the distributed self. But the distributed self is not enough because we are both distributed and regrouping. For me the age of the distributed self is also the age of the tattoo, and with a tattoo the reaffirmation of the boundary of our bodies. And by the way it is quite interesting that the return of the ornamental is also accompanied by a kind of strange generalisation of tattoos.

So "who are we?" is as fundamental a question for architecture, a question as important as "how should we design architecture?" because both are inseparable. I think this is probably the most important thing to remember in my talk.

Where do I want to go? To the following: there is actually, once we accept all these premises, still a fundamental question: what about the computability at work all over the world? If matter, if the real are defined as the computable, is there any room for something that is not computable? It is a very serious question for cities, for example.

Today I am having a heated debate with Carlo Ratti and a couple of other friends as well as with students because, for example, urban modelling is back. With big data, you have a lot of people following the kind of Santa Fe Institute belief that cities are going to become computable.

We are beginning to observe the same trends in architecture. Think of all the people who tell you today "you know what, architects, you design these fancy buildings but what about the lessons of neurosciences?" After all we are beginning to know more and more about the way the brain functions, and when you mention sensors, you have people who say let us equip people with sensors, throw them in the city and observe their reactions. Using these observations, we will know better how to design urban spaces.

What if architecture was becoming computable? And you have, once again, a number of people who think that architecture should be determined entirely by computation, a computation including how we almost mechanically react to our environment, or to be more sophisticated, let us not use the old modernist metaphor of the mechanical but cybernetically react to our environment.

I think that the only antidote, and that will recall some things I have heard this afternoon (I did not do that on purpose but it is actually quite striking how things I have heard are a little bit in sync with what I was planning to say), is to remember that architecture is political. And we should define probably the political as the thing that disrupts the mechanism of computation.

Architecture is political, but how to be political without relinquishing the autonomy of the discipline? We all know that architecture and politics have a complex relationship. Stylistically, despite Bruno Zevi's claim that modernist architecture was inherently more democratic etc., we all know that you can enrol whatever style, mode of composition for whatever regime. In the 1930s, Albert Speer did neo-neoclassical, and the Americans did neo-neoclassical, so did the Soviets. Today, blobs are relatively apolitical. So how to be political?

To answer this question, one probably needs to go back to this idea of the physical embodied experience. And I would suggest that architecture is not political in the sense of simply serving a political agenda. What architecture does best, for me, is to create potential. To create situations with the potential for humans to act. I do not know whether you have ever had this experience: you enter an empty theatre, there is a stage and you are just with a couple of friends and one of them goes on the stage and what he says or she says becomes different just by the fact that he/she is on the stage. I think architecture is a way to frame human actions so that they acquire relevance. It does not completely tell you what to say, although a theatre strongly suggests that you play or make dramatic statements, but it does orient human action, and above all suggests that human action has a relevance.

An example of what architecture can do in terms of the situation is rather concrete. It is about this idea of architecture as a stage, this is a project from one of my friends at Harvard, Rahul Mehrotra, and it is nothing dramatic, it is basically a facade, an intelligent facade in the Indian way, as well as a green facade. Basically, there are people tending a vertical garden. But what this project is about is that inside you have .com people, from the high castes of India and outside you have almost the lowest ranked in society, and usually they do not see each other. Architecture forces them to see each other and Rahul told me once that his biggest success was that actually the people who tend the garden put their best clothes on now. Because they know that it is one of the few moments in Indian society, which still tends to disregard a lot of people, when they are visible.

Architecture helps to structure and modify what French philosopher Jacques Rancière calls an aesthetic regime, that is to say, who can see what, who can be seen by whom in a given society. Although it seems little, it is actually loaded with consequences.

In a more benign genre, Chicago architect Jeanne Gang, when she designs balconies from which you can see the occupants of the other apartments in a Chicago tower, she also creates a new situation that alters the dominant aesthetic regime. Usually Chicago high-rise residential housings are about seeing no one from the building. You are each facing the lake and see no other person. To be able to see someone else is actually quite a revolution in the American psyche, and in high-end condominium design.

In conclusion, architecture should think of itself in relation to the issue of materiality, especially today. Through its relationship with materiality, it can act as a disruptor in a world that some would like to become entirely computable. In other terms, we need a true politics of architectural materiality.

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Antoine Picon

is the G. Ware Travelstead Professor of the History of Architecture and Technology and Director of Research at the Harvard Graduate School of Design. He teaches courses in the history and theory of architecture and technology. He is also Director of Research at the Ecole Nationale des Ponts et Chaussées in Paris. Trained as an engineer, architect, and historian, Picon works on the history of architectural and urban technologies from the eighteenth century to the present. He has published extensively on this subject.

Four of his books are devoted to the transition from early-modern societies to the industrial era: *French Architects and Engineers in the Age of Enlightenment* (1988, English translation 1992), *Claude Perrault (1613–1688) ou la curiosité d'un classique* (1988), *L'Invention de L'ingénieur moderne*, *L'Ecole des Ponts et Chaussées 1747–1851* (1992), and *Les Saint-Simoniens: Raison, Imaginaire, et Utopie* (2002).

With La *Ville territoire des cyborgs* (1998), Picon began to investigate the changes brought to cities and architecture by the development of digital tools and digital culture.

INTERVIEW

ROLAND SNOOKS AND JÜRI SOOLEP

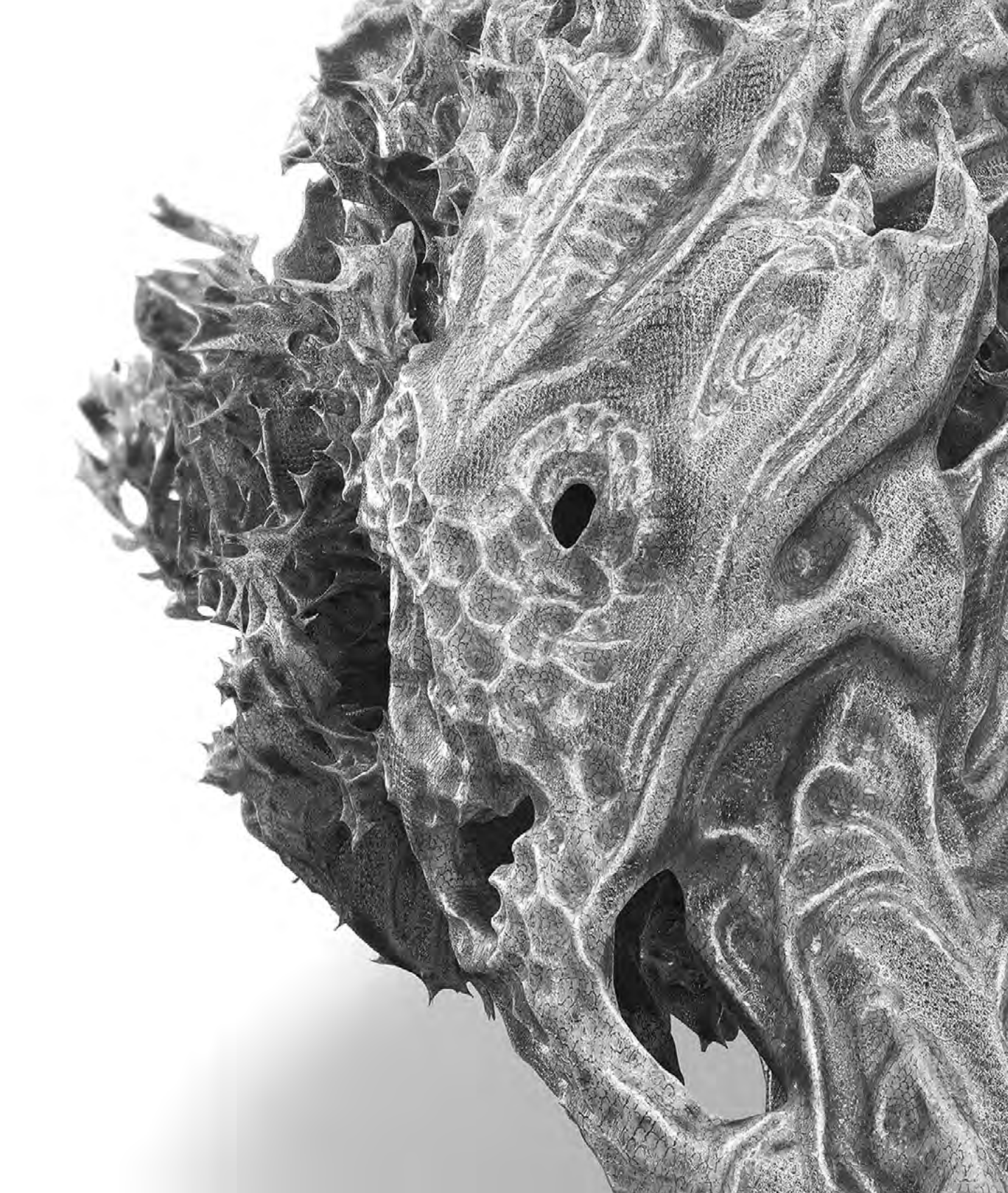
9 September 2019,
Estonian Academy of Arts

JS: We are at the Estonian Academy of Arts and I have here our keynote speaker for the conference Space and Digital Reality, architect Roland Snooks. I understand you have been in Tallinn before. How did you know about the biennale and how did you happen to be so far from your place of residence – Australia?

RS: Well, yes, this is my second time in Tallinn and the first time was four years ago for the Tallinn Architecture Biennale. In that biennale we exhibited a small installation, that looked into the relationship between algorithmic design and new types of fabrication. In particular we were looking at fabrication through fibre composites and the carbon fibre and glass fibre complex forms, which embed structure and ornament into an expressive surface as well as how to do this without mould making. I guess that was my introduction to Tallinn and perhaps that association is one of the reasons why I am back here this time.

JS: I leave the second question about Tallinn to the end of the interview, because it would be really interesting to see how you describe the many layers of space in Tallinn. Our conference is based on an assumption, that there is a large paradigm change going on – both in architecture and also in building. The current situation and the current technologies of architecture that are changing were actually advanced and have their birthplace in the Renaissance. For me there are three components there: First, architectural drawings, the architectural representation of the space. Brunelleschi and Alberti were the ones to really tie it together in Cartesian imagination – the plans, sections and elevations and made it a mathematical and geometrical document. The second element there was authorship in architectural creation. It was Donatello and Alberti who really established themselves as the authors of the design. Alberti even, as far as I know, forbade the architect from going to the building site. Then the third, which is probably more arguable, but Brunelleschi already had a totally modern organisation of the building process. Shifts of workers, lunches, the materials coming in and also the mechanical instruments like cranes and other lifting machines. Architecture has changed as an expression, as a cultural layer, but actually these very technological elements of architecture and building have remained the same. Now all three elements are changing: we have algorithmic, parametrical design. We are losing the author and also the manufacturing is becoming totally different. How is your work approaching that type of paradigm change? Or do you agree that there is such a change?

RS: I think there is. I think that obviously our Biennale film established the notion of, intention of authorship and the abstraction of the drawing. I think authorship from time to time comes into question and is undermined in different ways and sometimes that is very productive. I would say that the work that I am a part of is really a sort of second digital movement in architecture and perhaps if you can describe the first as being associated with the likes of Greg Lynn and some of the works coming out of Colombia in the 1990s, of course, I am well aware that there was very important digital work going on before that – people like John Fraser, but I guess, Greg Lynn in particular ways was trying to undermine authorship and he was trying to set up a series of, in his case, dynamic general processes in order



to partly bring time into architecture and to register the effects of time, but also to set up a generative strategy which changes the nature of authorship, but not necessarily the degree of authorship. I would say that in generative design, authorship shifts from being an act of invention or sort of direct authorship into something that is more about curation. Some people talk about generative design as designing a design process rather than designing a thing or it can be discussed in terms of setting up the conditions from which the object emerges.

So definitely the work that I do is part of a movement in terms of generative design, which I trace through Greg Lynn and can also be traced to people like Gaudi and of course the sort of well-known hanging chain models. So I think that yes, authorship is shifting, although one thing that I realise in the work that I do – it began with an interest in generative design and this idea that we can set up conditions where all of architecture might emerge from the bottom-up process – I began to realise that I am actually much more interested in the relationship between bottom-up processes and top-down processes. And where does intention and authorship lie in those, how do you encourage your intention into our world which might generate something and how do you begin to interact with others in much more direct and deliberate ways.

JS: If you mentioned Greg Lynn, do you think how the undermining of authorship in this case was a result of technology, the type of methods and ways of designing or was it kind of deliberate cultural change in attitude?

RS: I think it was a cultural change. I think it was very much responding to an intellectual milieu around anthologies of becoming and processual ways of thinking and obviously he was drawing heavily on Gilles Deleuze in the early 90s. So, I think it was inherently a conceptual and perhaps ideological position which was aided and embedded by technology. I think that often when there are shifts in architecture, it is when a confluence of the conceptual as well as the technological happens. When those things align, then I think there are changes. The case of Gregg Lynn in the early 90s was one of those moments.

JS: What about the manufacturing that is now definitely coming into a totally different level than before: a group of people used to come together and use some skills and knowledge to put the materials together and then the designed object emerged. Now that has changed at a very fast pace.

RS: Yeah, I think that there is obviously a shift that has been happening for several decades now around the move from mass standardisation to mass customisation. I guess this is one of those moments where systems of fabrication are quite aligned with systems of design so in terms of algorithmic design and parametric design we have a series of tools which allow significant differentiation and now we have a series of digital fabrication and robotic fabrication techniques which similarly allow that type of differentiation and I think the two combined are creating, and this has the potential to contribute to quite a different type of architecture.

JS: You were mentioning Deleuze and in a way that takes us back to Plato who was in a way dividing the world of ideas and concepts and then the world of becoming which is in constant change. How would your approach to this algorithmic architecture line up with Leibniz, who had this idea of monads which was a kind of nucleus which then gradually developed into a full-bodied object or even event or phenomenon. And it was not necessarily clear from the beginning where it developed from and so it had a kind of agency of free will inside.

RS: Well certainly our work does not draw directly on Leibniz, but I guess, if there is a parallel it is something around the idea that something small, in our case it is actually really a bit of code or behaviour or sort of protocol, that is then able to generate something that is much greater than itself. But all possibilities are contained within that original behaviour. I would probably align that – in a way I came to be doing this type of work also through reading Deleuze and Brian Massumi. I was interested in this notion of the abstract machine and the idea that was often talked about as a diagram and my interpretation was to talk about the abstract machine almost as an algorithm, so a set of procedures, and when that set of procedures is located in a different circumstance, it can potentially

generate vastly different things. I guess that is some of the theoretical points of departure, that led to the work I do.

JS: Maybe this is the right time to also ask which teachers or which authorities in the world of architecture have influenced you or can you refer to the schools of thought that you feel part of?

RS: Well, I studied at several schools, but most influential, in terms of my trajectory, was beginning at RMIT, where I did my undergraduate degree and then later at Colombia. In Melbourne they had very early adaptors of computational techniques. This comes through the work of in particular Paul Minifie and it was really being a student of Paul's that got me interested in computation and generative design. Also, Pia Ednie-Brown who I guess had an influence in directing some of the more theoretical concerns in the work and her obsessions around anthologies are becoming really influential for me. I also studied at RMIT under Mark Burry and of course Mark had played a very similar role in the development of parametric associative modelling in architecture. While I was at Colombia, probably Karl Chu was a great influence on my work, I studied under him and I guess that sharpened a lot of my thoughts around the generation of architecture, generation of form. He sparked really fascinating debates around the sort of morph generic and morph dynamic on some of the quintessential aspects of architecture. So, I guess they were people who directly influenced me, I guess I should also say that Ed Keller also had a strong influence on me, he was another professor at Columbia at the time. But then more indirectly I was, as said before, I was influenced by Gregg Lynn's early work. And then also really influenced by some more esoteric architects and I think that is probably, the more my work develops the more I realise their sort of strong influences. I am interested in the work of people like Gaudi, but I think that Gaudi is often simplified and he is sort of understood as, you know, something about generative design and an obsession with geometry, but actually I think that there is such a greater richness to Gaudi and I think that it is the esoteric parts of Gaudi that are interesting to me, not the kind of universal parts of Gaudi. Other architects like the American architect Frank Furness, who worked in Philadelphia. He is somebody who is always sat on the outside of architecture, always outside sort of on the fringes of it. These were some really strange architecture and these are the people that I really admire.

JS: It is interesting you bring up Gaudi and I agree, he is slightly simplified in the history books even in Watkin's *A History of Architecture*, the stone and steel structure buildings are referred to as concrete, pioneering concrete buildings, which they are not really. And from my experience, I think the Palace of Güell, which is so rich, he was definitely using very different concepts and at the same time he was extremely technological with brick. So, I think you reminding us of Gaudi is very valuable here. It in a way explains another layer of your work for me, which I have been looking at. My next question would be maybe, to simplify things, to ask about algorithmic architecture. We use that term and we roughly understand what it means, what it deals with – it deals with algorithms, but there are other elements like emerging architecture, parametrical architecture, and architects are good at inventing new terms just to explain it for themselves, to have self-assurance, but also for advertising. Could you roughly give us your idea of what is what and how it works.

RS: Yeah, sure. I think so many of these terms get conflated and, of course, people are always inventing terms and then the conception of the words differ – there is not always necessarily a precise definition. I would say that it is important to describe something like parametric design. I would say that parametric design is (or associative modelling) is simply about the linear relationship between a parameter and a geometric transformation. So, this is entirely a kind of linear and direct way of operating and a very flexible way of operating. I mean there is a lot of very good uses. My criticism of parametric architecture would be to say that all possibility is already contained within the starting condition. The full range of possibility is already established by establishing the parameters, there is nothing which can emerge in that process. I should say that it is also important that the term parametric or parametricism is being co-opted by Patrik Schumacher and he uses a much more generalised way – he uses parametricism as a term to cover everything that involves the computational

or digital. So, he has sort of stripped it of its original, precise meaning. And his notion of parametricism is constantly about evolving, so it is hard to pin down in what moment or time it is. If you try to describe what parametricism is, you have to describe it on a particular date. So then to come to algorithmic and emergence – an algorithm of course is simply a procedure, it is like a recipe, a set of instructions, which usually operates recursively or intricately. I guess the great power in that way of working is that it can be non-linear, so the output of a process can then become the input process and you get a feedback loop and through that feedback you are able to create a complex system. From complex systems there is already the potential of emergence. So, emergence can be thought of as a complex system that gives a rise to emergence; it creates something which is greater than the sum of its parts and also makes it non-reduced to its parts. I guess this is something which has had a big impact on the type of work that I am trying to do, I mean it really comes out of complex sciences and it comes out of an interest in emergence and the volatility of those processes. One of the key things I would say is that between a non-linear algorithmic architecture and a linear parametric way of working, one of the real key differences is risk, speculation, and I think when you have a process which is stable and you set up the conditions and you know that which is going to occur. Everything happens within that known range – there is no risk to that, there is no real speculation, it is just setting up a possibility of creating a variation, whereas if you're working through a complex system, which are often also described as chaotic systems, these are systems which are potentially highly volatile and I really think it is in these highly volatile states that something new can emerge. This is why I am inherently drawn to emergence and to non-linear ways of working – it is that potential for something less known, I guess, to emerge.

JS: And algorithmic then would be a kind of overarching definition of architecture that is based on algorithms, whatever complexity they really use.

RS: I guess there is a huge variation in what those might be. For example, the algorithms that I am interested in, are algorithms in which you are writing the behaviours of architecture, in a way. And so, you try to take design intention and code it into a set of behaviours and through the interaction between those behaviours then looking at the way something has the intention to become self-organised. Something might emerge from that.

JS: Now is probably the right time to ask the following. I was looking at your PhD presentation which was roughly five years ago so you have come a long way from there, but I understood from the beginning of your presentation that there are three layers in your work: First, the will or the nature of the algorithm itself, which is linear. Second, the intention or the will of the designer who makes decisions somewhere within the process and then, third, the general design intentions or the designing as a process. Have I interpreted that correctly and have you developed that further now that you have had more practice since your PhD?

RS: The PhD is really looking at the relationships between emergence and intention, so part of that comes back to questions of authorship which we were discussing earlier. I guess systems of emergence or complex systems are often thought to be systems outside of intention; they seem to have a life of their own. But I think intention, when you are designing through these systems, operates in a whole series of complex ways. On the one hand, as an architect you write the rules of the system, so you write a series of behaviours and then as it is generating things you are evaluating that based on a series of intentions and criteria as an architect and then feeding that information back into writing the algorithm, to change the parameters. And then, as I was saying before, a lot of the work that I am doing is really about the relationship between bottom-up and top-down and so we are often interfering with those algorithms as well on all sorts of scales – designing things that go into the algorithm, pulling things out of it, sort of manipulating things and putting them back into the algorithm. This becomes quite a messy process. So, one thing that I tried to include in the argument in the PhD, was whether intention can be encoded into algorithms. I think often algorithms in contemporary architecture are selected because the architect knows what it is going to produce, rather than it being speculative. I became interested in algorithmic architecture because of the capacity to speculate through

it, to do something experimental, to do something which is volatile, something less known. And so to use it in an experimental way, where you can set up the conditions for something and not entirely know how it is going to play out, which is not to say that you do it at arms-length or that you do not have control or authorship, I mean you certainly do, but it is a process that you constantly interact with and hopefully it leads to something which is far from the initial conditions. But I think that what happens in contemporary architecture is people see what an algorithm does and they will often select an algorithm which has a very … what I would describe as an indexical relationship to the outcome and we can see this, often when we are looking at contemporary algorithms and how they work, we immediately see what algorithm was used in it. What that tells me is that design becomes an active selection, because of people selecting the algorithm because they know what it creates rather than as an act of speculation.

JS: Like choosing tiles – different colour, different texture ...

RS: Exactly, and it is depressing to say but at its worse that is what algorithmic architecture becomes – a selection of algorithms. I think the real key is to be able to define or develop algorithms in which you can really encourage really direct architectural intention and this is why I am interested in multiagent algorithms because they are a very open platform in which you can write a whole series of different behaviours that relate to different concerns about architecture and those do not get destroyed within that process, I mean those intentions; they have a really meaningful impact on what is created as it kind of goes through that process.

JS: But before we go on to multi-agency, there is another interesting theme I wanted to ask about: how would you explain that the output of your work is extremely spectacular. It is well published, there are conceptual developments and processual developments, but they also look spectacular. So, how does it happen to be that your work is in that first category? If it is algorithm driven, there is this emergence that you were talking about, but nevertheless, in one case it becomes spectacular and in other cases not.

RS: I have an obsession with forms and I have an obsession with the things that we create out of these. So there is a whole series of ideas and concepts that run through the work, some of which I have explained around the processes of generation, but I am also interested in some of the other ideas that come out of the complexity of the synthesis of things in the way that some of these processes negotiate whole series of different concerns in a single body of matter. I am quite interested in this idea that modernism was interested in seeing things as discrete and separate, the way that structure and scheme and all the elements of architecture could be drawn separately. Hence, things like, there is a really interesting relationship between drawing convention and architectural ideology, so you know the exploded axonometric and its role in modernism, I guess is a really key one in that everything can be exploded and everything can be described as being separate. I often find myself talking to my students and consider it to be a failure if you can draw and explode axonometric off the work and the reason for that is that I am interested in the way that a single body of geometry is able to negotiate between structure, ornament, surface and form, all at once. And so, rather than seeing these things as discrete and separate, they are synthetic. There is a whole series of ideas that I am working through, but at the same time I am absolutely obsessed with form, its relationship with structure and ornament. This relationship between structure and ornament is a kind of classic architectural problem, which has been worked through by every architectural paradigm and I am trying to work through it in the guise of complexity and in complex systems. But at the same time, I think the work that I am doing is very deliberately esoteric. It is not trying to make a sort of universal model and I think that if it is spectacular at times, maybe it is because of this absurd obsession around those types of forms, which are driven by sort of very personalised and perhaps an esoteric set of concerns.

JS: Can it be the case that you have come that far in going through the algorithms that your conscience in a way drives you toward certain poetics, poetics in concepts and in forms, which you probably could also include when you say esoteric.

RS: Well, I think intuition is an important thing in this work and I think the way that you develop systems which you can work through intuitively and in some ways it seems maybe odd because you have something that is highly systemic, you know computational algorithmic work is a highly systemic thing, but I think what can leverage that most powerfully is working through ways that are highly intuitive and highly creative and so I would say that the work that I do is, it embraces objectivity, it embraces individual intuition, which I think is different from a lot of my peers who are interested in computation. I think that there is a certain segment of computational architecture which gravitate towards rule-based design, I suspect because it is an attempt to try and avoid design decision-making. Like it is looking for the absolute, it is looking for the objective, it is looking for a way in which decisions can be described as an objective set of criteria, which can be established, that avoids the necessity for individual intention, which I think is deeply worrying, saying that is what my work is engaging.

JS: I think we can now come back to these highly systematic layers and I wanted to ask you about swarm intelligence, could you tell us about that. And then I want to ask you about artificial intelligence. Let us start with swarm intelligence.

RS: Okay, so swarm intelligence describes collective behaviour in things like schools of fish, social insects, any type of system in which you have a series of individual entities, often described as agents and where the interaction of those agents leads to the emergence of behaviour which is greater than the sum of its parts. So, we see this in nature, but we also see this in things like economic markets – we can see them operating in the same ways. And if you want to try and generalise a multiagent model, you can describe almost anything in the world as coming about through this type of system because it is simply about the way one entity responds to entities immediately adjacent to it. Through the mutual feedback of those, then something else emerges through that process. There are certain people, like Stephen Wolfram, who would argue that the entire universe can be described simply as cellular automata. I would not make that argument myself but I think that he has a very generalisable approach. So, my interest in swarm intelligence is not an interest in trying to make architecture biological, it is not in trying to make architecture swarmlike, flocklike in some way, instead it is about the idea that you can have a series of behaviours which interact with each other and give rise to something. My interest is not biological behaviours, but very much architectural behaviours, as though you can write the behaviour for the emergence of architecture. And this is quite different again to someone like Patrik Schumacher, who is interested in multiagent systems, where he is interested in stimulating humans. I do not find this a particularly compelling way of designing, it is a good way of analysing something, in the same way you can analyse structure through finite element analysis. If you analyse what might happen, you might be able to analyse how people might use the space, but that is very different from this idea of understanding the behaviour of inhabitants, of people, whereas I am trying to talk about the behaviour of architecture or the behaviour of the process of formation in architecture.

JS: Certain topographies or localities come out from there.

RS: Yeah, well I think these rules can, I mean the types of behaviours you write – some can be very direct like they can be very much about a structural principle or about a certain relationship between one piece of geometry and another, whereas others might be much more speculative around creating complex systems from which something highly expressive might emerge. So, I guess the way that I am trying to look at it is that, if this is a system which can negotiate between a whole series of different types of intentions, then you do not need to privilege one or another in a sequential way. There has been a whole lot of, in my opinion, interesting and reductive discussions of course in the history of architecture around questions such as form and function and the quintessential relationship between those, but in complex systems those can negotiate with each other without one having a prioritised importance over the other. So you can simply write a set of algorithms in which function, form, structure, ornament all interact simultaneously and it also becomes a battle in terms of the way they negotiate all of the things simultaneously and I think one of the interesting effects of that is, what I would describe as a decoupling of

the architectural role from architectural geometry. Often in architecture, but of course not always, there are artificial elements which have a one-to-one relationship to architectural roles. So, a column, a piece of geometry which takes vertical structural load and so there is an architectural element which has a clear architectural role. What I am interested in is the idea that an architectural role can be thought of as behaviour and then the geometry might negotiate between a whole series of different behaviours, so you might have a piece of geometry which is part of a structure, perhaps it's part of the scheme, perhaps it's part of the ornamental or all these things at once rather than having a sort of one-to-one relationship between the architectural role and geometry.

JS: Do you think this kind of synthesis also produces an effect of sustainability in a way that you use exactly that amount of material and geometry that is optimal for whatever task you describe?

RS: I think it would certainly make an argument around sustainability through this type of work. I do not typically foreground that argument, that is not the sort of priority in my work, but a lot of the work I do is around additive manufacturing, 3D printing and you asked, I did not answer your earlier question when you asked about how my work has developed since the PhD and I guess one fundamental change is that perhaps the generative design method has not developed that far in the last five years, what has developed has been how this gets built and then how the building of these things has an impact on design. Maybe come back to that later, but this question around sustainability – if you are using additive manufacturing, then of course you are able to precisely use material without offcuts and waste and 25% of building construction is waste and since building construction is such a large portion of the energy and materials used in a world where this actually has a huge impact. Of course, working through additive manufacturing where you can build much more complex forms, there is a potential for those forms to be much more highly optimised and the way we currently build, of course, through sheet material and through linear structural elements, these are not very efficient forms in terms of material use. They are very efficient in terms of the construction paradigm; I mean we make things out of sheet and so it is much easier to make things which are straight etc. So I think that through additive manufacturing, that potential argument, and of course the point that I am making about the synthesis of things, there can be one body of material which does all these different things at once, then yes, there is potential for sustainability because you do not have a separate element for structure and for the scheme and for ornament if they are compressed. But at the same time the work that I am doing is not, is definitely not about optimisation and in many ways I am sort of interested in excess and redundancy and the way, for example, that the excessive structure might take on another role, like if the structure is purely optimal, it has one type of expression, but if there is a structure which is roughly optimal, but has a certain redundancy and excess to it, that excess perhaps takes on another role which might be ornament for example – more expression. So, I guess I do not foreground the sustainable argument, but there certainly is a position around sustainability which can be made a claim for in this type of work.

JS: If we were talking about swarm intelligence, I would now like to go on to artificial intelligence. It is developing at a huge speed – Raymond Kurzweil in 10 years hopes he can be uploaded into the internet systems and live forever. They say that artificial intelligence will probably be so powerful in 2030 that economic and military decisions can easily be left to different artificial intelligence systems. When you are talking about swarm intelligence, of course there can be different levels of complexity of agents and rules for the agents. But if we take ordinary cellular automaton, for instance, the rules are very simple. If we take humans then it's all very complex. Can it be said that artificial intelligence is a top-down system and swarm intelligence is a bottom-up system? How would you expect artificial intelligence to develop? And how can that be compared to what you have been designing?

RS: I think this is a very interesting question. I agree with you. I think that swarm intelligence is inherently a bottom-up system, where you as the designer are interested in writing the underlying rules for something. This is really different from concepts around machine learning and big data for example. Big data reports are premised on dismissing the underlying models of things or the elements of underlying

models and simply acknowledging that if you have enough information about the surface effects of things then you can make predictions about what will occur. I think it is inherently dangerous in many fields. I think one of the reasons why it is dangerous is because it assumes that there is no structural change in the underlying models that generate these surface effects. I think if you really want to understand reality you need to understand the underlying model that drives reality, not simply the surface effects that lead to it. But in architecture we are not actually interested in understanding reality necessarily. We're interested in creating something. I think these tools get co-opted in different ways. I understand the criticisms of multi-agent algorithms and things like economic theory and also the limitations of the way physics-based processes are often applied to social structures and human decision-making. I think that often they do that because there's this surface correlation between the two, but the set of underlying principles is actually completely different. I think that there is potentially great danger in that type of work. But in architectural design we are interested in the generation of something and the quality of the things we can generate. In many ways we can use steel techniques from other areas. But coming back to your question about artificial intelligence. Multiagent systems rely on local interaction and it is through all these local interactions that something at the macro scale emerges. And they have something I describe as global ignorance – it is a necessity not to understand everything. Because if they did understand what the whole, say the swarm, was doing, they would all act in unison. And it is actually through this unity that individual interactions with something complex comes about from the system. The problem for architectural design through multi-agent systems is that lots of aspects of architecture cannot be understood at a local level. Like, you cannot for example analyse structural load at an individual point. You have got to understand the flow of structural load through a whole system. Or, you can't understand enclosure or spatial topology by analysing one point on the surface. So for agents that are ignorant of these global conditions, you need a whole set of ways for dealing with those. I guess a lot of the work I have been doing is partly about this top-down bottom-up relationship, where we will model some things that are at the global level and then at the local level agents are reforming things. I think there's great potential for artificial intelligence and machine learning in this role because machine learning seems to work at its best when analysing the global top level of things. So, part of the research we are doing in my lab at RMIT is around using machine learning and its interactions. So, machine learning is dealing with a series of global conditions and feeding the information back to multiagent systems which are dealing with them the bottom-up way. It is quite early in this research, but I am hopeful that this will end up with these two systems which are diametrically imposed actually creating a really interesting balance. But that is my interest in machine learning. I think that machine learning is beginning to become a quite popular thing in architecture. I think it is like any adoption of a new tool, it is often used definitely in a simplistic way and I think one of the dangers of machine learning is that a lot of it is based on existing data sets. So, you have to have a whole lot of data about something to then go train the model to be able to reproduce things that are within that framework. But I think the architecture that I am really interested in does not really exist in the known frame. So, if you train a model based on what is known then you are going to create architecture within that frame. For somebody who is interested in an inherently speculative way of working, that is kind of problematic. I think that that is one of the key things we will have to work our way around as a discipline in terms of artificial intelligence. I mean, do we end up just using artificial intelligence to replicate what we already do? Which I think would be profoundly uninteresting.

JS: Yeah, but also one can imagine that AI does not necessarily reproduce known models. And it has this kind of creative agency that tests things in so many different versions. Architects, in a way, have been proud in the modernist society up to now, that there is this value added through the design, which I agree with in the case of good architecture. But I have a kind of black scenario that comes into my mind. In certain ways if we look at the world today it has become more populist and simplistic, more global. At the same time, there are several things that are rather sophisticated peaking upward from this populist layer or I would even say this kind of primitive layer prevails to a certain extent. How easy it would be to create

certain living models for artificial intelligence and then through parameter systems to actually adapt it to every user. I am afraid that artificial intelligence has developed far enough that it is already better than human beings in all kinds of games, and planning very soon. So on the level of average architecture, it will probably be better to create that model for that person and then, of course, we have authorship in creating artificial intelligence and the parametric model, but after that it is really that everybody in a way does whatever they want within that system of parametricism. And if I look at the media level at the moment, how populist and primitive it has become, would we not face the same in the spatial relationships, that the lowest quality of human needs are actually then incorporated into the space through these top-down and bottom-up systems and then automatically printed whenever there is a possibility?

RS: Yeah, I mean it is kind of a worrying scenario.

JS: I am glad you do not believe it.

RS: I mean, automation is something that the whole world is rapidly grappling with, in all fields. I am certainly somebody who is engaging the tools of automation. In fact, I am engaged with the algorithms and the robots. I think the really interesting thing for me is what comes out of those is not the automation of things, but it is the things that were previously impossible. I do not know how it is going to play out, I guess. I hope it is not the scenario that you were describing.

JS: Me too, but nevertheless ...

RS: But I am hoping it is not that scenario. But I also think that the profession of architecture … I do not know what it is like here in Estonia, but the profession of architecture feels like it has been in a long slide … or constantly undermined, disenfranchised in many ways. And I think that has happened through a loss of control over the building process. I think architects were once central to that, now we are considered to be a sub-consultant along with a whole myriad of other consultants. And I think that now there are software companies attempting to try and further that in many ways. I mean, AutoDesk is clearly very interested in defining generative design and incorporating it into their software with this idea. They think of generative design, it appears to me, to be around topology automation. They can see the way that a series of conditions can be described that can then be optimised through the topology and then that can be 3D printed. In many ways that is a kind of attack on the architect's profession. This is the idea that architects too can be automated out. Perhaps there are a whole series of things that architects do that can be automated out, but I think that what this is probably leading to it is a really reductive architecture, which reduces the individual end to differentiation, to create a sort of homogeneity. I mean, of course some architects are very interested in the idea of the universal. Mies was very interested in the universal. Schumacher is interested in the universal. So maybe to some people this is not a concern, that it should be embraced. Having realised that my concerns are much more esoteric, I find these sorts of shifts toward universality kind of horrific or certainly worrisome.

JS: I will make a slightly longer comment now. If we look historically, the Renaissance was bringing up the drawings which were necessary and made the building process much easier in a way, much more efficient. Before Brunelleschi, scarcely maybe ten people understood the geometry the same way in the previous centuries and operationalised it in the same way. The cartographers were there always, they could manage it. But it was Brunelleschi who brought this geometry into the plane, into the representation or image. Then both the image and the conceptual geometries inside it was a rather complex thing to learn. And it gradually developed, but still until the 50s and 60s it was the draftsmen who actually made the drawings. Could be the architect, could be a technician, but on top of this knowledge and skill of making drawings was also the learning of composition, spatial structures, cultural inheritance. All of these things in a way came as an addition to the skill of making drawings. Now anybody can make the drawings with the help of software. Even with primitive artificial intelligence, the automation is in the software. Anybody can design even a complex building. So it is, in a way, true that technology has changed now so much that architects, because they are not the sole incorporation of these drawings skills, are also thrown out of this system, the

extra value which is much more important. This spatial composition and understanding of social processes and creativity within these spheres have also been thrown out along with the drawing skills. And I have a diagnosis for this. The optimist would say: "Perfect, this will allow all the creativity of people to come forth. The world will be much richer."

RS: Because they are not constrained by technique.

JS: Yes, anything is possible. A pessimist would think: "That would be a kind of global dilettantism, a kind of amateur level as has happened to the popular media and social networks where things are devalued to very basic levels." How do you feel about this? Outside of architecture, this dilettantism that is happening and gradually coming the spheres of art and architecture. Not so much in music, yet, but could that happen also there? Are you a pessimist or an optimist?

RS: I think I am inherently an optimist.

JS: Good.

RS: But on this question … Yeah, it is true that there's a whole lot of understanding of architecture which is bound up in drawings and to strip away the drawing, you strip away a lot of that understanding. I think you can see that in a lot of contemporary digital work. Working through drawings in a skilled way, there is a very clear understanding of the scale of buildings. And I think that when you see a lot of work that's perhaps designed by younger architects often working in more up-stylish firms through software that was originally developed for the animation industry or the product design industry, there is this real lack of understanding of scale which often leads to these sort of grotesquely outsized forms. And so take that as an example of where there is a certain loss and it is a very simple one about scale, not one about some of the more important things that you were discussing in terms of cultural understanding that is embedded in those. But perhaps there's a flipside as well which is interesting. Of course, with the Renaissance separating the drawing from building it also stripped out a lot of expertise.

JS: Of course.

RS: It stripped out expertise about material and about construction, about craftsmanship. And that was obviously deliberate. But I think there is a whole series of technologies now which allow it to be reinvigorated. Of course, there is a well-known discourse around digital craft in the way that access to digital fabrication techniques and robotics allow architects to have an understanding of persistent construction, which informs design and which can lead to a greater richness of design, I believe. So maybe these tools are … Yes, there are certain things that get lost in the shift in techniques, but then perhaps we need to embrace all the things that are reinfused or can be infused into architecture. I guess this is part of what you are asking and another part of that question is probably really around almost co-design. And because I firmly believe in expertise, I think that architects are well placed to make design decisions, perhaps even better placed than an amateur. Even though I use a series of tools which are about distribution in terms of design through multiagent systems, the decisions come from myself as a designer. It is not literally distributing decision-making into a field of users, for example.

JS: You might say that you are making the decisions on some kind of meta level, in a more abstract way. These levels as you were explaining about your work can go several layers up and become more abstract than very exact design decisions.

RS: The other way of looking at this question is around the prevalence of 3D printers at home in the last decade. Perhaps a decade ago there was a lot of enthusiasm about everybody having a 3D printer and people can then download, customise and print things out themselves. Of course, it has not quite been realised. 3D printing has not become as ubiquitous as perhaps people might have thought 5 or 10 years ago, but I think the outcome of that has been the wholesale production of shit, where people are printing a whole lot of bad things. I'm not convinced that the ability to print your own creation necessarily creates better things.

JS: Surely not! But I think it might still come, because 3D printing has not become mainstream on every street corner, yet. And also, size matters here. I am looking forward to that type of makers' cooperatives where you can go and either cut or print according

to the drawings, something you want or imagine. I do not think the technology is there yet on the mainstream level. It might be that new technologies come even faster, as it happened with these huge CDs that were coming out and never really got to the market. So yeah, it might be the case that new things come before the technology is really fully developed. I agree.

And thank you very much. It has been a very interesting insight into the conceptual world that you cannot really see from your drawings and illustrations.

It is said that Estonians, being inhabitants of a very small country, are always interested in what others think of them, although nobody is actually interested in them. But allow me a question of a more professional kind. You came here from a rather diverse background. How would you describe architecture in Tallinn? I don't mean whether it's good or bad in a contemporary sense. If you had to describe it to your students, what layers would you bring out from Tallinn urbanism and architecture, which we can look upon because you have a fresh and maybe uninterrupted impression of the space?

RS: Well, this comes from a position of very little understanding. I have spent only several days in Estonia.

JS: It is perfect then.

RS: But a few things strike me about Estonia which I think are pretty interesting. One that seems to exist on a general level is this great enthusiasm for innovation in Estonia, it is great, particularly technological innovation, it seems to me. It seems that does extend to the design disciplines. But also, it seems to me there is an interest in the relationship between technological innovation and craft as well in traditional industries. And some of the work that I know is happening in contemporary architecture in Tallinn is about the intersection of new computational techniques and traditional timber fabrication, for example, and what that might lead to. That is very interesting. Another thing, it seems there are much looser hierarchies in Estonia, much more fluid interaction across generations. It does not seem to have such established hierarchies which can be quite stifling. I guess the other very obvious thing for an Australian in a country which obviously has an indigenous history of architecture, but that's a very pneumatic sort of architecture. But Western architecture there has a very short history, 200 years, and so to come to a country which has such a layered architectural history is fascinating. It is certainly fascinating for an Australian to be here.

JS: Alright, thank you for very nice words.

Post scriptum

JS: It was really great to hear about these things. I was looking this morning partly through your PhD presentation, so I got some kind of background, of course I have seen your work beforehand, but I have not been particularly interested in that type of architecture myself.

But this spectacular reason which you explained through esoteric intentions is very interesting. That is something that gives a kind of key to understanding, which I did not possess before when you talked about it, so that is highly interesting.

RS: Well, when I started my PhD, I thought I was writing a PhD about the architecture of swarm intelligence as though it is some generalisable model that I could describe and it could be disseminated and people could adopt to it and use it as sort of a way of designing. And then it was actually quite late in the PhD in the last month or so of writing the PhD that I realised that it is really not what I cared about. And actually, what my obsession with the projects themselves and the qualities and the characteristics and what aspects of those that I thought made them unique or somehow different from other work. It was really about doing that when I realised that I was interested in the specific rather than the generalisable. Maybe esoteric is not quite the right word. I struggle to describe it really. Also, I struggle to describe it without it sounding glib with a certain kind of desire for uniqueness or novelty. I'm certainly trying to create things which are unusual. I have noticed some of my friends and contemporaries who are doing similar types of things, I guess.

I can see some of them at this great design and create something that can be repeated and they want everybody to repeat that.

JS: Yeah, that is awful.

RS: I think I have a greater version of that. I have sort of privileged the strange, unique and unusual. Those are the things I am tempted to try and create.

JS: What I also think is very valuable from your presentation was how you could analyse your own design work. With all these schemas you were showing – what goes where and what has been in your opinion the triggering or conceptual part; how they fuse and become apart. I think that is something that would be extremely valuable for a PhD by design or project-based PhD to give that example and develop a rather detailed account of your own self-reflection. That would be something I am thinking we could definitely use if you come back again some time for PhD students here. There is a huge confusion about what practice-based PhDs are. There is all kinds of nonsense coming out, but we think that some good work is also emerging because of that nonsense. One can look for a kind of detailed structuring or depiction – what you did and how you did that part of your work. That would be very valuable, I think as a part of a lecture and maybe as a part of a publication as well. I do not know when you will come back, because we cannot fly you in for a guest lecture now and then, because that is slightly far. If you are in Europe, it would be very good to do that kind of seminar for PhD students. I mean including students in the fine arts who also struggle.

RS: I think, now that I'm done, I can see the value in a reflective practice-based PhD. I think like any model there are successful ways of doing it.

JS: But it takes a certain intelligence and rigour to bring that to a level that is useful. Which I think in your presentation, it was there.

RS: Oh, thank you. I think it is partly about afflicting on the work and understanding your work in ways that are useful to other people. Like the way that you can describe something which is not about navel gazing or something, but it is actually about really explaining the underlying drivers and what they do. But then also being able to tie that into a context that is much greater than the word itself. I think that the other sort of two things that I think probably need to go together, is to have a successful reflective study. I think there are some reflective PhDs. Of course, there are some that become quite introverted.

JS: I have been at the Adapter meetings two-three years ago, which took place in Gent. Many of them were very disappointing experiences. Presentations from tutors were kind of ... I would not accept it as a necessary level for PhD. But now when I look at Siim and Sille and the other work that is coming out of there, I think it has lifted itself to a newer level. At least I hope so. I am very critical about the RMIT model that was imported to Europe. Actually, I was at the beginning of it. It is a very funny story. It was Johan Verbeke, me and Halldor Gislason from Iceland. We were having a meal in Lille for some kind of conference. I was pushing Johan and Halldor that we should make a PhD school together, because this is the problem here always. We do not have critical mass. The Danes and Swedes think they do have a critical mass, but they actually do not. The work is so diverse. We were thinking that if we can push this kind of fun European thing; I had had experience with Toomas Tammis. I do not know if you have met him. He is a professor here and the previous dean before Andres Ojari. And we were going to a PhD school in Venice and it was one of the first of these multiagent PhD schools. The idea itself and the system was very good. After every two months, the PhD students gathered somewhere in the participant cities. Then they had lectures and presentations. So, I was thinking of something like that and talked to Johan and Halldor. Johan then went and wrote it. Later on, he asked us to join that which he had written on his own. Because he just took the burden of it and he had the RMIT experience previously, because of the connections there. He was an external examiner quite often there in Australia, I understood.

Roland Snooks

is the director of the architectural practice Studio Roland Snooks and a co-founder of the experimental research practice Kokkugia. Snooks' architectural work explores the emergence of intricate formations from self-organising processes. He is an Associate Professor at RMIT University in the School of Architecture and Urban Design, where he directs the RMIT Architectural Robotics Lab. Snooks has previously taught widely in the US including at Columbia University, University of Pennsylvania, SCI-Arc and the Pratt Institute. Snooks' design research is focused on the development of behavioural processes of formation that draw from the logic of swarm intelligence and the operation of multi-agent algorithms. He received a PhD from RMIT and holds a Masters in Advanced Architectural Design from Columbia University, where he studied on a Fulbright scholarship. His work has been published and exhibited widely and has been acquired by the permanent collections of the Centre Pompidou and the FRAC.

DESIGN, AUTOMATION, AND COMPUTATIONAL BRUTALISM[1]

Mario Carpo
Bartlett School of Architecture,
University College London

Architects and designers invented the idea of digital mass-customisation in the early 1990s, and the first practical experiments in non-standard serial production famously followed soon thereafter. Back then, however, designers using new CAD/CAM technologies faced drastic limits in the choice of materials they could work with, and in the size of the pieces they could fabricate. In Greg Lynn's seminal Alessi Teapots, a non-standard series of 99 variations of the same parametric model, each of the 99 teapots looked alike and was meant to be seen as a monolith – a single metal block: that was in fact not the case, but was nonetheless the idea the series was meant to convey, and this is how each teapot would have been fabricated, if titanium sheets could have been milled, 3D printed, or extruded. However, when trying to apply the same logic to a non-standard series of actual buildings (the *Embryologic Houses*, circa 1998–2000), Lynn (2000, 26–35) was the first to point out that those fabrication processes could not easily be scaled up. The shell of a parametric, non-standard house could be made of a vast number of digitally mass-customised, non-standard panels, but these in turn would have to be fastened to a structural frame, and to each other; the frame itself, due to its irregular form, should have been laboriously hand-crafted, and so would each fastening nut and bolt and junction and joint between the parts. In short, twenty years ago Lynn's non-standard house would have ended up being more hand-made than digitally fabricated.

The transfer of non-standard technologies from the small scale of product fabrication to the large scale of building and construction remains to this day a major design issue. Some digital makers have tried to duck the issue by enlarging the size of their printers, but as printing machines tend to be larger than the objects they print, this has resulted in a number of quixotic experiments with rather unwieldy hardware. Today, the versatility of robotic machinery leveraged by the *brute force* of big data computation suggests a different approach: instead of printing bigger and bigger monoliths, it may conceivably be easier to start with any number of parts, as many and as small as needed, leaving to AI and robots the task of sorting them out and putting them together. Today, thanks to AI, an almost unlimited number of different (or identical) parts can be individually notated, calculated, and fabricated; and, also thanks to AI, an almost unlimited number of different (or identical) robotic gestures and movements can be scripted and executed for their assembly. The technical logic of digital mass-customisation (the mass production of individual variations at the same unit cost of mass-produced identical ones) is perfectly mirrored by the technical logic of AI driven robotic assembly: identically repeated robotic gestures cost the same as variable ones; robotic operations of similar amplitude or duration will cost the same whether the actual robotic movements are the same or not.

In fact, as both fabrication and assembly can be standardised (making identical copies, or identical gestures, respectively) or non-standard (making variable copies, or variable gestures, respectively), it is easy to compile a mathematical matrix of the four resulting modes of combined production and assembly – of which one, the standard assembly of non-standard parts, appears improbable; the remaining three describe most of the experiments now being carried out by computational designers around the world. Moreover, standard fabrication, non-standard fabrication, standard assembly, and non-standard assembly, can all be delivered by dint of manual, mechanical, and digital processes (at least in theory, but with the exception of non-standard production and assembly, which can only be achieved manually, or digitally). The bigger matrix resulting from these additional combinations could in turn be applied to describe the quasi totality of architectural history.

Given this vast gamut of possible outcomes, one may reasonably wonder why some very particular design

1 Excerpted and edited from an earlier essay written as a preface to Retsin et al. (forthcoming).

options appear, at present, to be more actively pursued by the design community around the world. What some have called "excessive resolution," or the style of big data – the voxellated style of discretism and particlization – was, and still is, the outward and visible sign of an inward, invisible logic at play that is no longer the logic of our mind (Carpo 2017, 70–79). Traces of this aesthetic sensibility can be found in various aspects of contemporary design, sometimes for cultural and technical reasons unrelated to computation (as in the recent works of Kengo Kuma), sometimes even in the absence of any technical consideration whatsoever (as in some works of Sou Fujimoto). On the other hand, similar technical considerations also underpin the chunky style that, at the time of writing, is the marque of the Bartlett school of computational brutalism (but also to be found in work produced at SCI-Arc, USC, the MIT, and elsewhere). The peculiar chunkiness that characterises it follows from the averred predilection of some designers for the non-standard assembly, or combinatorial assembly, of a finite catalogue of standardised, even prefabricated parts. Given the technical premises of robotic automation, as described above, this predilection may appear quirky, and arbitrary. Assuredly, if new technologies exist today that allow us to mass-customise any assembly of parts, why should similar – indeed, often older and more established – technologies not be used to mass-customise the parts themselves?

Parts readied for robotic assembly need not be identical, nor identically reproduced; likewise, automated, robotic gestures need not be identically repeatable: in both cases, endless variations may come, theoretically, at no extra cost. Why is it then that brutalist chunkiness is now so often seen to be associated with robotic automation? Why are so many computational designers today tinkering with modularity, combinatorics, and prefabrication? In purely technical terms, none of that makes any sense today, as the marginal costs of computational production are (in theory) always flat. And if the reasons for today's computational brutalism are eminently non-technical, what are they then?

One hint … perhaps not unnecessary … we are talking about design here, and there is more to design than technical optimisation. True, computer scientists largely agree that the novel, often truly astounding, technical performance of today's computational tools is the main reason for many recent breakthroughs in AI. Yet today's dataism is more than a linear accretion of information and processing power; what some computer scientists call, somewhat dismissively, brute force computing is in fact a new set of problem-solving methods (hence a new kind of science) triggered by today's unprecedented data affluence and computing speed. In architectural history, however, the term Brutalism has a quite different lineage, and harks back to a different set of meanings, ideologies and values. Considering where and when this is happening, and what is at stake for the present and future of the world in which we live, and of the ideas in which we still believe, the rise of a new school of computational brutalism in design, conspicuously drawing from both traditions, may not be coincidental.

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Mario Carpo

is a Reyner Banham Professor of Architectural Theory and History, the Bartlett School of Architecture, University College London. Carpo's research and publications focus on the relationship between architectural theory, cultural history, and the history of media and information technology. His *Architecture in the Age of Printing* (2001) has been translated into several languages. His most recent books are *The Second Digital Turn: Design Beyond Intelligence* (2017), *The Alphabet and the Algorithm,* (2011); and *The Digital Turn in Architecture*, 1992–2012, an AD Reader.

THE NEW NORMAL: A GOODBYE TO LANGUAGE

Roemer van Toorn
UMA School of Architecture
Umeå University, Sweden

Abstract

We are at the beginning of a new *renaissance*, a new modernity, of which we are far from sure what it will bring or could enlighten. As an institution, architecture has always directed our sensuous experiences and conceptual understandings of the worlds we live by and look out for. The power to create images is a good partial definition of architecture's competence. In my opinion, architectural imagination – and that very much includes the image – can be a staging ground for action, enlightening individuals and cultural movements. An enlightenment not as universal truth, but as temporality, one of provisional possibilities and lines of flight. Instead of disqualifying the spectacle – as the classical left used to practice in the safe haven of academia – we should investigate how ethical spectacles could be created. To do so is not simple. A spectacular culture is most often designed to manipulate people and take their money, not to set the stage for democracy. But at the same time, we have to recognise that popular culture – its crafted fantasies and stimulated desires – speak to something deep and real within us. The challenge is what these ethical spectacles could consist of. This urgent question is by no means an easy one, but without a framework of understanding and alternative theory, any means of instrumentality will be futile.

Keywords: imagination, image, ethical spectacle, revolutionary conservatism, cosmopolitan outlook

Jean-Luc Godard (right) and Fabrice Aragno during the filming of *Adieu au Language* (*Goodbye to Language*), 2014. A French-Swiss experimental narrative essay film written and directed by Jean-Luc Godard. Copyright Kino International / Everett Collection.

Introduction

I believe we are just at the beginning of a new *renaissance*, a new modernity, of which we are far from sure what it will bring or could enlighten. As Jüri Soolep outlined – "the way we personally communicate, use and, to some extent, even alter the digital reality is mostly in the form of the visual image" (2008). In fact, architecture has always played an essential role in this throughout history: as material practice representing, embodying and making alive social, political, cultural and economic values through its different projections, and forms of organisation. As an institution, architecture has always directed our sensuous experiences and conceptual understandings of the worlds we live by and look out for. As Michael Hays has noted the power to create images is a good partial definition of architecture's competence (2016).

When thinking about the possibilities of contemporary architecture today, the work of anthropologist Arjun Appadurai helps us to understand that the idea of imagination can also be a staging ground for emancipatory action, and not only for an escape into commodification (Appadurai 1996; Appadurai 2014). In my opinion, the architectural imagination – and that very much includes the image, and the visual culture it brings with it – is a staging ground for action, with the power to engage individuals and cultural movements to open up journeys of enlightenment (Davidson and Ponce de Leon 2016).

What can we say about the image, the culture of the visual, the many interactive screens and cameras, directing, creating, helping and manipulating our dreams and desires? Do we still see the world if we are constantly looking at our screen? I believe we have to think with images again, start to look again because images govern our dreams and our dreams drive our actions – imaginations are, as Appadurai said, a staging ground for action. Instead of disqualifying images in our age of total over-visibility – what a lot of *lazy* critique sees as the only option – I hope to make clear that we must embrace the image (in opposition to the visual). We need to start to see again, beyond language, no longer rest aside and be judgemental (as in Academia), but have to experiment and speculate, become popular again, be able to connect to the world, create imaginations against the reactionary populism which helped Trump to become elected in the first place.

Two points help me to imagine anew: First, we have to understand that we are living a rather bizarre moment in time. What I myself and others have called the new normal (Burkhardt and Morozzi 1997; Bratton 2015; Bratton 2017; van Toorn 2019). This new normality

US Armed Recruiting Station, Times Square, New York City, United States of America, 2012. Copyright Roemer van Toorn.

of circumstances and outcomes we must map and understand anew. As Benjamin Bratton observed the language of hybrids – which we are used to, to help us, to make sense of it all – will not help us to grasp this new normality. Secondly, we need to address what kinds of normative claims can be enforced in this arising new normality through the advancement of digital technology and its digitised cultures of images. Not only should we question our sovereignty, tools and methods, but look for how this new normality can challenge and inspire us about what possible futures of civil imagination could be conceived. What other images, instead of visuals, can be produced, and what its normative agenda could be concerned with, is the question.

The new normal, a goodbye to hybrids

Recently writer and artist Douglas Coupland flew over a Cajun swamp in pursuit of purple lights in the distance. Then he collected asteroids in the rings of Saturn. When he removed his virtual reality headset, he looked at his favourite room in the world, filled with good friends on a beautiful summer evening, and thought, "Man, what a dump: 'Reality is toast.'" (Coupland 2017). Coupland's example, the recent selfie-architecture of people climbing the highest skyscrapers to take a selfie, Elon Musk shooting his Roadstar to Mars, the #metoo movement, bitcoin millionaires, Donald Trump's alternative facts, Moscow distortions of reality, Edward Snowden NSA leaks, or the many Drone perspectives, and "illegal" USA killings making many victims, Las Vegas luring millenniums via new forms of entertainment, art becoming virtual, questioning robotisations, etc. These are just some of the many bizarre and shocking moments that suggest a new normal is on the horizon within the functional stratum of layers that specifies and links heterogeneous technologies together within our globalised world. And for architecture and the city the consequences are enormous.

The first thing that architecture could do (and is starting to do) is to map these bizarre circumstances anew if it wants to design a future for humanity. We are no longer living in a time of one satellite in the air (sputnik) or a single TV beside our bed, or table. The impact of the virtual and its image has become total (Ferraris 2014). When something new appears, we may understand it as a combination of familiar things at first says Benjamin Bratton: "A car is a 'horseless carriage'. A handheld computer is a camera plus wireless data – a 'mobile phone', a metropolis woven with networks of sensors and information technology a 'smart city'. Blockchain 'digital money', and so on" (Bratton 2017). Hybrids made sense remarks Bratton "by way of an analogy and continuity, but soon they create confusion, and even fear, as the new evolves and resembles the familiar less and less. Hybrid terms delay recognition and defer understanding of what requires our most sincere attention how it really works."

"I just want to thank Google for teaching me how to find love. While looking for my estranged brother, I stumbled across a Mexican Web site for male strippers – and I was shocked. My brother was working as a male prostitute! The first chance I got; I flew to the city he was working in to liberate him from this degrading profession. I went to the club he was working at and found my brother. But more than that, I met one of his co-workers … We got married last weekend [in Mexico], and I am positive without Google's services, I never would have found my brother, or my husband. Thank you, Google!" The new normal of interlacing things – as we have just read in this Google User testimonial (Friedman 2005) – is not a hybrid; it is a normal thing (Friedman 2005). Once the gap between what our hybrid concepts try to explain and what is happening become so widely normal, we need to move on to new words, new concepts. Thanks to digital technology and the third industrial revolution, we can no longer navigate or think in linear terms, hybrids, or *eitherorism*. It takes too long to walk with you through a glossary of new terms beyond a hybrid understanding to help us understand the new normal and its many different fields we are confronted with. What I like to do instead – as I already mentioned in the introduction – is to focus on the image as such. With this note we arrive at part 2 on the normative claims and dimensions of the imagination.

A goodbye to language

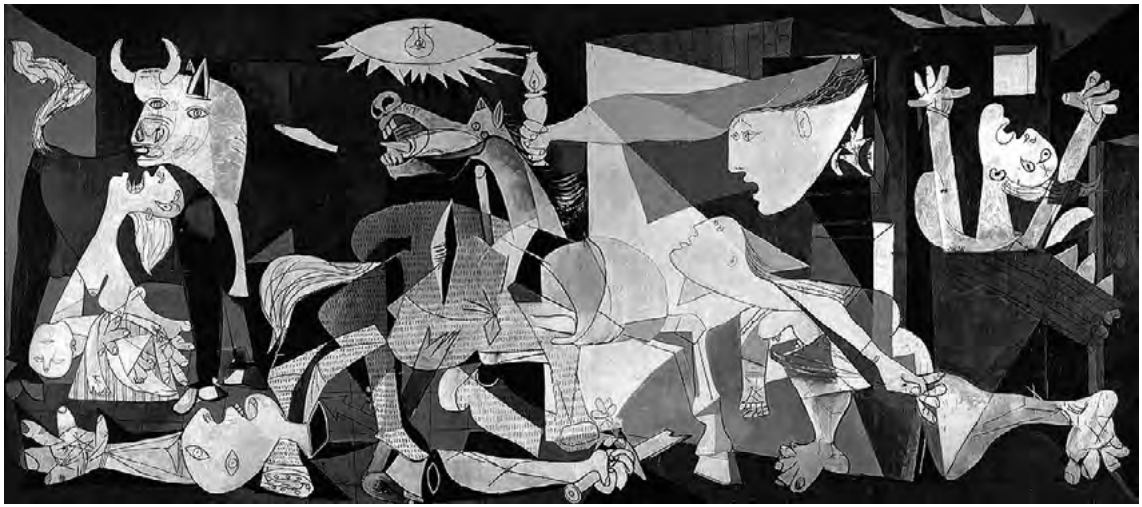
Critique has been the primary mode of resistance, but a growing dissatisfaction with the political capacities of critique is emerging in the face of the many crises,

disasters and mutations our bewildering modernity is producing. Instead of ignoring the real becoming virtual, we better deal with it. Such an approach we find also in filmmaker Jean-Luc Godard's work. In his film *Goodbye to Language*, he uses all kinds of 3D cameras to construct a narrative (Godard 2014). Instead of disqualifying technique, he embraces the opportunities a new technology can bring. "3D technology is still an area where there are no rules," Godard says (2014). "There are plenty of rules once you've invented them, and I'm then less interested because there are only rules: it has to be done this way or that. Whereas, when technique is at the very beginning, like a child, it has no rules." Godard uses the new technology to build up a multi-layered, richly textured image poem of sometimes breath-taking simplicity and beauty. The film *Goodbye to Language* pushes 3D technology beyond its boundaries to create a visually disorienting experience, and as is the case in most of Godard's films, the end result features a montage of images that had never before graced the big screen. The naked bodies of our two protagonists look tangible and malleable. The foreground and background are so dramatically pronounced, the viewer can peel back each visual layer: an iPhone creeps forward while the bookseller stand shrinks back, an old movie plays on a television screen as the woman undresses in front, and a dog explores either a technicolour forest or the space that lies between its image and the background. To my mind the film theorist Serge Daney can help us to understand what the differences are between an image and a visual: "The visual keeps us from seeing (because it prefers that we decode, that we decipher, that we "read"), the news shows us the facts, we understand what we see through the visual: a person is shot. Instead the image always challenges us to carry out a montage with others, with some other. Because in the image, as in democracy, there is 'free play', unfinished pieces, gaps, openings" (Daney 1997).

The idea of the democratic image of Daney should be understood in opposition to what Vilém Flusser has called the technical image. In his book *Into the Universe of Technical Images* (Flusser 2011), he explains that the universe of the technical image has for centuries made use of photographs, films, video, television screens and computer terminals to take over a task formerly served by linear texts. This cultural revolution has now become interactive with the arrival of the web and handheld devices, such as tablets, mobile phones, drones, sensors, etc. When images supplanted texts, says Vilem Flusser, we experience, perceive, and value the world and ourselves differently, no longer in a one-dimensional, linear, process-oriented, historical way but rather in a two-dimensional way, as surface, context, scene, even three dimensionally now thanks to RD cinema and VR. And our behaviour changes: it is no longer dramatic but embedded in fields of relationships. What is currently happening is a mutation of our experiences, perceptions, values, and modes of behaviour, a mutation of our being-in-the-world everywhere and nowhere. Instead of the image, I prefer to speak of the universe of visual technology. Vilem Flusser is correct, but with the concept of the image I like to investigate and point in another direction that makes use of the visual, but creates, what Stephen Duncombe has called "ethical spectacles" (2007).

Instead of the many city spectacles, and smart cities becoming places of "spectacle-ization" (Urry 2007), increasingly made dependent on what city marketeers make of our imaginations. Instead of disqualifying the spectacle altogether we should investigate how ethical spectacles could be created that surpass the traveling circus of "cultural capitals" full of cultural and historical theme parks. To do so is not simple. Spectacular culture is most often designed to manipulate people and take their money, not to set the stage for democracy. But at the same time, we have to recognise that consumer culture – its crafted fantasies and stimulated desires – speaks to something deep and real within. The challenge is what these ethical spectacles could consist of. This urgent question is by no means an easy one, but without a framework of understanding and alternative theory (such as the one on display here), any means of instrumentality will be futile.

As Orit Halpern reminded us in *Beautiful Data: A History of Vision and Reason since 1945* (2015), *Language of Vision*, by Gyorgy Kepes (1969), discusses excellently how Picasso's *Guernica* evokes according to Kepes an "optical fury" and "the shrieks of danger siren." *Guernica* itself, of course,



Guernica by Pablo Picasso. Photo: Laura Estefania Lopez, 2017.[1]

was a reference to the Fascist bombing of civilians in the Spanish Civil War. In looking at this image says Halpern, Kepes argues that it succeeds because it creates contact between a plastic, modular structure and the trace of history – "social events." Kepes writes: "Picasso stirred to a fury of indignation by a human drama caused by the regressive social forces and their significance today, it is a visual projection of the discrepancy 'between life as it is' and 'life as it should be', representing human figures in a distortion of pain and suffering. Tears are in the action like a bursting bomb. The plastic interconnection of the lines, planes, and texture-surfaces acts as do suffering individuals. [...] Two contradicting systems, plastic organization – the message of order – and the organization of a meaningful whole – the message of chaos, are wielded in an indivisible whole". This image works in a manner different from advertising in Kepes' argument, says Halpern, because of the disjunction between what has happened (life as it is) and what should happen (life as it should be). Kepes is after images of "temporal disjunction" says Halpern, it is not about making engineering more playful or creative, but to challenge our imagination of life and technology.

1 Source: Wikimedia Commons. Licence: Laura Estefania Lopez / CC BY-SA (https://creativecommons.org/licenses/by-sa/4.0). Note: No changes were made to this image.

This idea of the image is related to what Francois Jullien says in *The Great Image Has No Form* (2012). *The Great Image Has No Form* explores the "non-object"– a notion exemplified by Chinese paintings that do not seek to represent observable surroundings. Jullien argues that this non-objectifying approach stems from the painters' deeply held belief in a continuum of existence, in which art is not distinct from reality. Contrasting this perspective with the Western notion of art as separate from the world it represents, Jullien investigates the theoretical conditions that allow us to apprehend, isolate, and abstract objects. Seeing with Jean-Luc Godard, looking for a democratic image, a great image with no form, I agree that we live in a time and need to say goodbye to language, text and words are still there, but lose their dominant role, play another, lesser role. It is the imagination that counts, and what we need to create are images, staging grounds for action beyond the universe of the visual. Kepes and Jullien show that there is a long tradition in painting to begin with.

Now that we understand, I hope, what images are about, what to think of the current new normality we are confronted with in such imaginary scapes as we have encountered in movies such as *Blade Runner 2049* (2017). Let us have a look at the hologram sex scene in *Blade Runner*. The scene has quickly become

one of the most talked-about sequences from the film, as much for its thematic implications as the striking visuals that went into it. Director Denis Villeneuve explained how he and the crew made the scene come to life. Speaking to *Vulture* magazine (Buchanan 2017), Villeneuve spoke at length about what went into making the scene from a technical standpoint as well as how he wanted to develop K's character as a result of the experience. In an effort to give the lonely K a chance of actually experiencing making love to a woman with a real body, Joi employs Mariette to represent her physical form as she superimposes herself, sometimes clumsily, over her. The result is a surreal yet strangely erotic scene that has become one of its most unforgettable moments. Villeneuve explained that the unsynchronised movements of both actresses during the scene was a deliberate choice, and a painstaking process to get right: "The way eyes move, or a hand … I felt the smaller the gesture, the more erotic and powerful the scene would be. [...] I loved the idea that you were feeling both presences of both women at the same time and that sometimes, it was like you were feeling a third woman." The director elaborated on how the scene was filmed, which involved the two actresses alternating attempts at mimicking each other's movements. The visual effects team reportedly worked on combining their shots for "well over a year," and for some of it even scanned 3D models of both Davis and De Armas to blend together. The slight imperfections in the resulting scene was Villeneuve's way of making it feel less "magical" and making viewers "feel the limit of the technology."

Although the imagination – on being virtual – becomes in *Blade Runner* very close to what awaits us in the future so to speak, I like to question the direction its disjunctive imaginary affect has; for instance, if you compare it to Picasso's Guernica. The action ground of the imagination in *Blade Runner*'s hologram sex-scene – let us say for the moment that it is an image (not a technical image) – what does it actually normalise, what is its normalising claim? I believe it is caught in a typical Hollywood perspective, one of identity politics, let us investigate what Nancy Fraser has to say about this. Recently, Nancy Fraser introduced the oxymoron: "Progressive Neoliberalism" (2017). "In its US form, progressive neoliberalism" – like Fresh Conservatism (van Toorn 1997) – "is an alliance of mainstream currents of new social movements (feminism, anti-racism, multiculturalism), on the one side, and high-end 'symbolic' and service-based business sectors (Wall Street, Silicon Valley, and Hollywood), on the other." In this alliance, progressive forces are effectively joined with the forces of cognitive capitalism. "The breaking down of cultural hierarchies is clearly to be welcomed, for the most part," however say "it is less the upshot of the genuinely democratic spirit than an effort of the commodity form, which levels existing values rather than contesting them in the name of alternative priorities," says Terry Eagleton (2016).

Stylish and exclusive Holiday Resort, Hof van Saksen, the Netherlands. Photo: Roemer van Toorn, 2018.

We should not forget that these forms of what you can call "Revolutionary Conservatisms" (Gilroy 2000) – free of any nostalgia as in classical conservatism – are neoliberal forces prepared to accommodate the new of "uncontrolled social forces, only in order to channel them," says Melinda Cooper: "into constantly reinvented forms of private wealth and family inheritance. [...] It is a speculative orientation toward the future poised between the self-revolutionizing orientation of credit-based temporality and the imperative of sustaining tradition via the private distribution of wealth" (2017). I believe we must imagine the possibility of something else based on a new idea of the common (collective) and the individual, based on the new normal arising today, and confront the many forms of struggle in concrete situations today.

Towards a cosmopolitan outlook

As Julia Kristeva notes already in 1991, "[W]e are, for the first time in history, confronted with the following situation … A paradoxical community is emerging, made up of foreigners who are reconciled with themselves to the extent that they recognise themselves as foreigners … In France, at the end of the twentieth century, each is fated to remain the same and the other – without forgetting his original culture but putting it in perspective to the extent of having it not only exist side by side but also alternate with others' culture" (1991). Now that we all belong to paradoxical communities, we have in fact become cosmopolitan; "citizens of the world." But we have to be careful and make a distinction between globalisation and cosmopolitanisation. Globalisation is primarily one-dimensional economic growth to be understood in terms of the free flow of capital, commodities and labour across national borders, says Ulrich Beck (2016). In contrast, cosmopolitanisation should be considered to be multi-dimensional, seeing it as a process that has irreversibly changed the historical nature of social worlds and the standing of states in these worlds. Cosmopolitanisation is about the development of multiple loyalties as well as the increase in diverse transnational forms of life. This "cosmopolitan outlook" (as Ulrich Beck calls it) – if we really observe her – "has its home in amazement," the same new technologies and the virtual being can bring, in the expanding in-between, in which seemingly eternal certainties, borders and differentiations become blurred and effaced. Here we find transcending identities, something we might think of in terms of multiplicities. Every individual must orient oneself – to find oneself – among one's multiple personalities, with the help of others (who can be abstract or ideal others: memories, stories, symbols or institutional emblems). In extreme terms, we need to ask ourselves the question, says Etienne Balibar, "can difference and sharing, conflict and the general interest be thought together?" (2014). This, according to Ulrich Beck (2016), "involves two things: on the one hand, situating and relativizing one's own form of life within other horizons of possibility; on the other, the capacity to see oneself from the perspective of cultural others and to give this practical effect in one's own experience through the exercise of a boundary-transcending imagination". I believe that this cosmopolitan outlook – relying upon the self-realisation of individuals to both critically reframe their own openness to the world and willingly act in a new cosmopolitan sensibility – can be sustained and developed with the help of architecture. Including its powerful institutional side, not only its trivial bottom-up practices, although sympathetic. In short this means that the arrival of the foreign(er) and the changes/chances it brings can in fact on many fronts stands central to the discipline of architecture as a source of ideas concerning the material and spatial construction of our human environment. In that sense, migration or the foreign fuels innovation, and should not be feared, on the contrary welcomed and supported. I believe there is hope for a future architecture based on an idea of civil imagination as a staging ground for action once the image and the foreign meet.

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Roemer van Toorn

is professor of architectural theory at the UMA School of Architecture Umeå University, Sweden. He has been in charge of the history and theory programme, and was head of publications at the Berlage Institute Postgraduate Laboratory of Architecture, the Netherlands 1993–2010. He was professor at the Delft School of Design (DSD), University of Technology Delft, the Netherlands, and guest professor at the Universität der Künste Berlin (UDK), Germany, while at the same time pursuing a career as an international lecturer. His work as researcher, editor, curator, writer and photographer has been widely published. In 1994, he published his first book, the encyclopaedic manifest *The Invisible in Architecture*. In 2011, his publication *Wiel Arets: Stills, A Timeline of Ideas, Articles and Interviews 1982–2010* was awarded Best Dutch Book Design. He has been the editor of several issues of the annual publication *Architecture in the Netherlands*, contributor as well as advisor for the magazines *Archis/Volume, Hunch, Domus, Abitare* and *Lo-Res*. As author and photographer he contributes to many national and international publications. Currently, he is finalising his PhD "Making Architecture Politically: From Fresh Conservatism to Aesthetics as a Form of Politics", at the Estonian Academy of Arts, Faculty of Architecture, Tallinn.

THE SOLID MATTER(S) OF DIGITAL NATURES

MULTISCALAR TECHNOLOGIES OF WORLD URBANISATION

Adrià Carbonell
KTH – Royal Institute of Technology
Stockholm

Abstract

This paper looks at the intersection of two fundamental paradigms of our time: the urban age and the digital age, and particularly at the way they are reshaping the idea and the materiality of our contemporary world. Furthermore, it brings a historical perspective by introducing the work of Ildefons Cerdà and his *General Theory of Urbanisation* as a precursor to data-based urbanism. If most of the international attention gathered around his work has typically focused on hygiene, circulation and morphological unity, most important for the success of his theory was the scientific and methodological organisation of a territorial system, from the collection and production of data and statistics to the design of legal instruments of space management. Finally, it explores how the emergence of digital technologies have defined a new theoretical and technological framework that triggered the process of world urbanisation. The interplay of geographical space and virtual space is scrutinised by looking at their material origins and effects in order to disentangle the multiple scales of digital urbanisation, from planetary networks of ICT to the urbanisation of the human body.

Keywords: cybernetic urbanism, urbanisation, big data, Cerdà, environment.

1. Introduction

We live in a historic time defined by a seemingly unavoidable yet continuous flow of innovation and change. As we are forcefully witnessing, the world is changing at a high velocity and so are the ways, technologies and standards against which things are measured, and therefore interpreted. Matters of scale, distance, speed, labour, as well as notions of body, space, territory, environment or world have all come to take new forms and meanings over the last several decades of the digital awakening. Digital technologies have propelled vast transformations in our social relations, but also in the material interfaces of our most mundane routines such as work, education, entertainment or trade progressively blurring the formerly differentiated spheres of private and public, leisure and professional life (Crary 2014). To be permanently and simultaneously connected to multiple screens is today a common scene in daily life in affluent societies across the world, to which we have uncritically become accustomed, with an almost holy belief in technological progress as a provider of welfare and prosperity. A life that is increasingly monitored by sensors and supported by automated systems. The ubiquity and interdependency of information and communication technologies (ICT), together with advancements of different kinds of virtual spaces, have shaped an image of a world with no matter or flesh, an assumption that symptomatically omits the origins and effects of digital technologies. For that, when thinking about space and digital reality, I would like to remind us of an elemental claim by media theorist and artist Sandy Stone:

"The discourse of visionary virtual world builders is rife with images of imaginal bodies, freed from the constraints that flesh imposes. Cyberspace developers foresee a time when they will be able to forget about the body. But it is important to remember that virtual community originates in and must return to the physical. […] Even in the age of the technosocial subject, life is lived through bodies" (Stone 1991).

In addition to the yet actual presence of bodies, it could also be noted that, even though information can circulate through a vacuum, it does through matter too, hence requiring a vast distribution network

Still from the film *Ready Player One* by Steven Spielberg. While the movie unfolds in the virtual space of a highly developed video game, the material conditions of the city in which the protagonists live and the spaces where they access the game are very precarious and worn-down.

of transmitters and receivers to carry the flow of data along with a multitude of other devices, from processors to broadband connections to servers to all sorts of interfaces, instruments and machines.

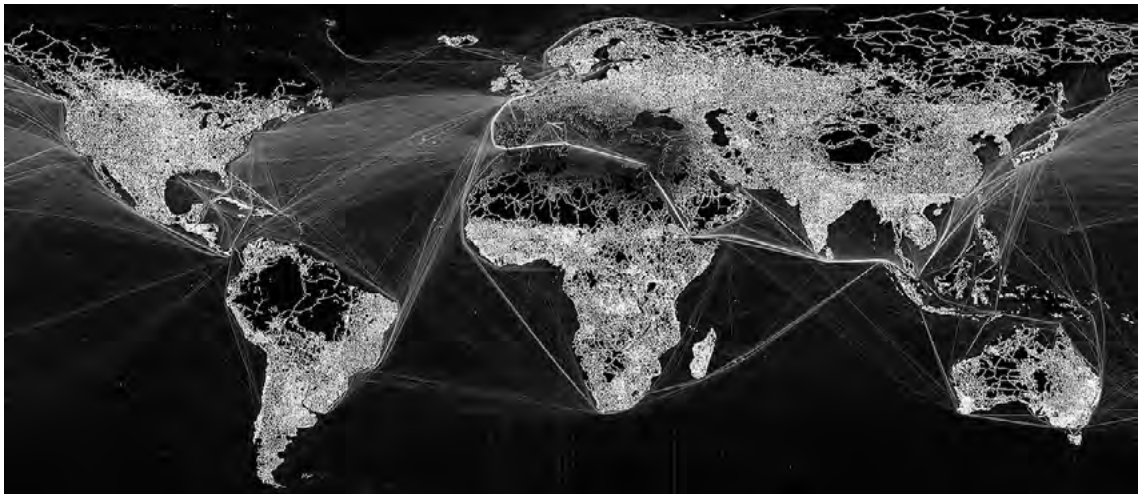
In his recent film *Ready Player One* (2018), Steven Spielberg vividly portrayed this duality between the virtual and the material world. The virtuality of a highly developed and sophisticated video game technology in opposition to a parallel collapsing reality, a city depicted as a scrapyard where the material conditions of living are of extreme scarcity. The movie depicts a troubling tension between cyber and physical space, between the reality of the virtual and the decay of the real. A hybrid condition that unveils the fragilities and paradoxes of the not always evident interplay between technology and space.

Drawing on this tension, in this paper I will bring together two fundamental paradigms of our time: the urban age and the digital age. In particular I will look at the way they intersect each other thus reshape both the idea and the materiality of our contemporary world.

2. Digital space and urbanisation

Information and communication technologies (ICT) have been for decades redefining space-time relations, and have triggered a radical reorganisation of the former space of the city, both in its materiality and its spatiality. The urban centres have expanded across territories following a process of decentralisation and delocalisation on regional, national and global scales. If time arose as a crucial element in geography in the 1960s, especially through the work of the Swedish geographer Torsten Hägerstrand (1975), cybernetics have definitely altered space-time relations, and heavily transformed the way we circulate and socialise, how data is produced and archived, even the very notion of space itself. As geographers Dodge and Kitchin have pointed out in their *Mapping Cyberspace*, "rather than being constrained by the friction of distance, we are increasingly constrained within a new geography of time which regulates access to people and resources" (2001, 14). Moreover, "the conceptual space supported by ICT, cyberspace, is extending social interaction through the provision of new media that are increasingly reliant on spatial metaphors to enhance their operation" (2001, ix).

Manuel Castells has theorised about an emerging spatial division being formed, where a new 'space of flows' is overlaying and increasingly controlling an old 'space of places' (1996). In turn, as Dodge and Kitchin suggest, "traditional geographic space is being supplemented by a virtual space allowing people and organisations to be more flexible in relation to real-space geographies" (2001, 15). Linking with an emerging narrative sustaining a process of the dematerialisation of the city, many have argued that cyberspace may lead to a placeless or even spaceless condition (Mitchell 1995). Nevertheless, it has indeed radically impacted and transformed the space of the world at multiple levels. Cybernetics and IC technologies have affected world urbanisation in both its extent and nature, and have propelled a decentralised but interconnected global urban system. This node-based web has also given rise to a new conceptual paradigm stemming from the notion of the network, which has redefined former spatial categories and scales, as so have the urban configurations informed by an economy of world-information-cities. Information technologies have increased the mobility and liquidity of capital while at the same time unleashing a global flow of goods and raw materials (Sassen 2005). Moreover, Saskia Sassen has shown how the economic processes of privatisation and



Global ground, marine and aviation transportation networks in the early 21st century.

Cartography and spatial analysis by Nikos Katsikis, Urban Theory Lab, based on data from: Road and rail networks based on the Vector Map Level 0 (VMap0) dataset released by the National Imagery and Mapping Agency (NIMA) in 1997; marine routes based on the Global Commercial Activity (shipping) dataset compiled by the National Center for Ecological Analysis and Synthesis (NCEAS); aviation networks based on the Open Flights Airports Database.

de-regulation that accompanied the rise of ICT provoked a rescaling of strategic territories at subnational (cities, regions) and supranational levels (global markets, free trade blocks) (2005). As Castells has shown, "economies of scale can be transformed by information and communication technologies in their spatial logic. Electronic networks allow for the formation of global assembly lines. Software production can be spatially distributed and co-ordinated by communication networks" (2010). Centre-periphery relations characteristic of industrialisation, as well as the relations between urban territories and their hinterlands, are superseded by a new global order. By adopting a logic of discontinuity and fragmentation, extended processes of urbanisation have essentially disrupted the modernist urban model. Holding onto this paradigm shift, some have argued that "geography is no longer a precursor to urbanism, the network is" (Lyster 2014). However, the reality is that cybernetic urbanisation has tightened the bonds between geography and urbanism, between city and territory, a relation which is by no means new, but that takes on another dimension in their overlap and intensity. Furthermore, in the process of adaptation to a global mode of capitalist production driven by a digitised economy, we have witnessed a dual phenomenon: on the one hand, the recentralisation and re-densification of urban centres, and on the other, the planetary expansion of urbanisation processes across geographies of land and sea (Brenner 2013; Peters et al. 2018).

Since the appearance of the first ATM machines, considered to be the first set of devices operating through an intranet, today human life unfolds over several billion interconnected things, to the extreme that digital devices and infrastructures are constituting a sort of environment, a technological nature where the intertwined web of networks, sensors and electronic devices are completely enmeshed in the urban habitat (Easterling 2012; Bratton 2016). Living a life entirely mediated by sensors and electronic devices is an undoubted reality that is increasingly generating hybrid conditions of matter and data, or as Antoine Picon puts it, of atoms and bits (2019).[1]

Devices of measurement and control are not only embedded in the built environment, but progressively becoming part of our outfit and soon to be integrated in our bodies, thus reaching a state where, as Jennifer Gabrys notes, "environmental technologies of ubiquitous computing inform urban governance and citizenship" (2014).[2]

3. Big-data urbanism

According to contemporary thinker Franco "Bifo" Berardi, "the subjugation of natural chaos by the humanistic order of measurement was the crucial feature of the cultural colonisation of the world by the Europeans" (2019). Big data is the apotheosis of measurement. If the modern definition of metropolitan life – of urban life – was paired with high velocity movement and circulation, a new condition has emerged with the digitisation of cities: being tracked down. Digital cities mostly rely on the production, processing, storing and management of data, which is also a type of circulation, but that has grown into a full category in itself. Through the use of geolocation and other embedded technologies, being in a digitised urban environment equals being recorded, quantified and monitored, thus being exposed to a high level of data production and management. The need for measuring and quantifying is consolidating a sensing environment (Gabrys 2014), which in turn is relaunching a project to recentralise urban spaces; the more compact and dense urban nodes are, the easier it is to collect data and map patterns of behaviour.

As Rob Kitchin explains, "the hype and hope of big data is a transformation in the knowledge and governance of cities through the creation of a data deluge that seeks to provide much more sophisticated, wider-scale, finer-grained, real-time understanding and control of urbanity" (2014), hence transforming the self-branded smart cities into "constellations of instruments across many scales that are connected through multiple networks which provide continuous data regarding the movements of people and materials in terms of the flow of decisions about the physical and social form of the city. Cities, however, can only be smart if there are intelligence functions that are able to integrate and synthesise this data to some purpose, ways of improving the efficiency, equity, sustainability and quality of life in cities" (Batty et al. 2010). Yet the explosion of big data comes with the associated question of what is the purpose and outcome of this metric paradigm, as well as the readability, accessibility and control over the data collected. Although the definitions and discussions around smart cities is not unambiguous, the implementation of a code culture is a relevant one. The question of "intelligence functions" arises here as a critical point. In other words, how can we make sense of an ungraspable amount of information, how can we "cook" the data, by whom and for whom[3]. Big data and real-time analytics aim to manage how a city functions and how it is regulated in a glorification of measurement, quantification and classification, thus giving rise to what has been called a metric culture: a metric colonisation of life itself. Yet again, this phenomenon is new only in its extent. In his book, *The Digital Condition*, the digital culture and media theorist Felix Stalder writes:

"What is new is precisely such large quantities of data ('big data'), which as we are promised or forewarned, will lead to a new knowledge, to a comprehensive understanding of the world, indeed to "omniscience". This faith in data is based above all on the fact that […] beneath or ahead of the social mechanisms of decentralised and networked cultural production, there are algorithmic processes that pre-sort the immeasurably large volumes of data and convert them into a format that can be apprehended by individuals, evaluated by communities, and invested with meaning" (2018, 103).

1 Antoine Picon delivered a keynote presentation at the conference Space and Digital Reality held at the Estonian Academy of Arts on September 11 2019 entitled *Atoms and bits: Taking their hybridisation seriously*.

2 In his critique of cybernetic urbanism, Maroš Krivý concludes that the smart city is conforming with a society of control as earlier described by Gilles Deleuze (Krivý 2018).

3 Attempts at calculating the colossal increase of data production have been recurrent since the emergence of big data. Google executive chairman Eric Schmidt stated in a conference in 2010 that the same amount of data was being created every two days at that time, as was created from the beginning of human civilisation to the year 2003.

Put in historical perspective, the faith in data and technology to shape a better society can easily connect with the reformist movements of the 19th century, when the rise of statistics was in fact enormous. Philosopher of science Ian Hacking talks about an "avalanche of printed numbers" emerging in the period 1820–1840, quantifying several aspects of life such as health, work or leisure. As Hacking writes, "statistics, in that period, was called moral science: its aim was information about and control of the moral tenor of the population" (1982).

In this tradition we could situate Ildefons Cerdà and his *Teoría general de la urbanización* (*General Theory of Urbanisation*) (1867). If most of the international attention gathered around the work of the Catalan engineer has typically focused on hygiene, circulation and morphological unity,[4] most important for the success of his work as an intended theory of practice, was the scientific and methodological organisation of a territorial system, from the collection and production of data and statistics to the design of legal instruments of space management. In his monumental treatise, considered to be the foundation of modern urbanism as a field of knowledge, Cerdà drew on the latin urbs to coin the term urbanism, with the ambition to establish a scientific discipline that aimed to unite spatial and social development in a technological and political nature. As Hacking points out, the motives behind the rise of the statistical enthusiasm were genuinely philanthropic (1983). A good example of this can be found in Cerdà's earlier writings:

"... if statistics were what they should be, they would tell us how many crimes or at least reprehensible acts are born out of the malaise that festers in the spirit because of the misery and discomfort engendered by the gloom of most of the dwellings in which many unhappy families in our towns are condemned to live" (Cerdà 1861, 881).

4 We find for instance a simplified reference to Cerdà's work in Batty's *The New Science of Cities* (2013): 'Ildefonso Cerda anticipated a world of cities based on a science of geometry and form as the substructure for social behavior' (13). Other recent accounts of Cerdà's Teoría can be found in Pier Vittorio Aureli, *The Possibility of an Absolute Architecture* (2011), or in Ross Exo Adams, *Circulation and Urbanization* (2019).

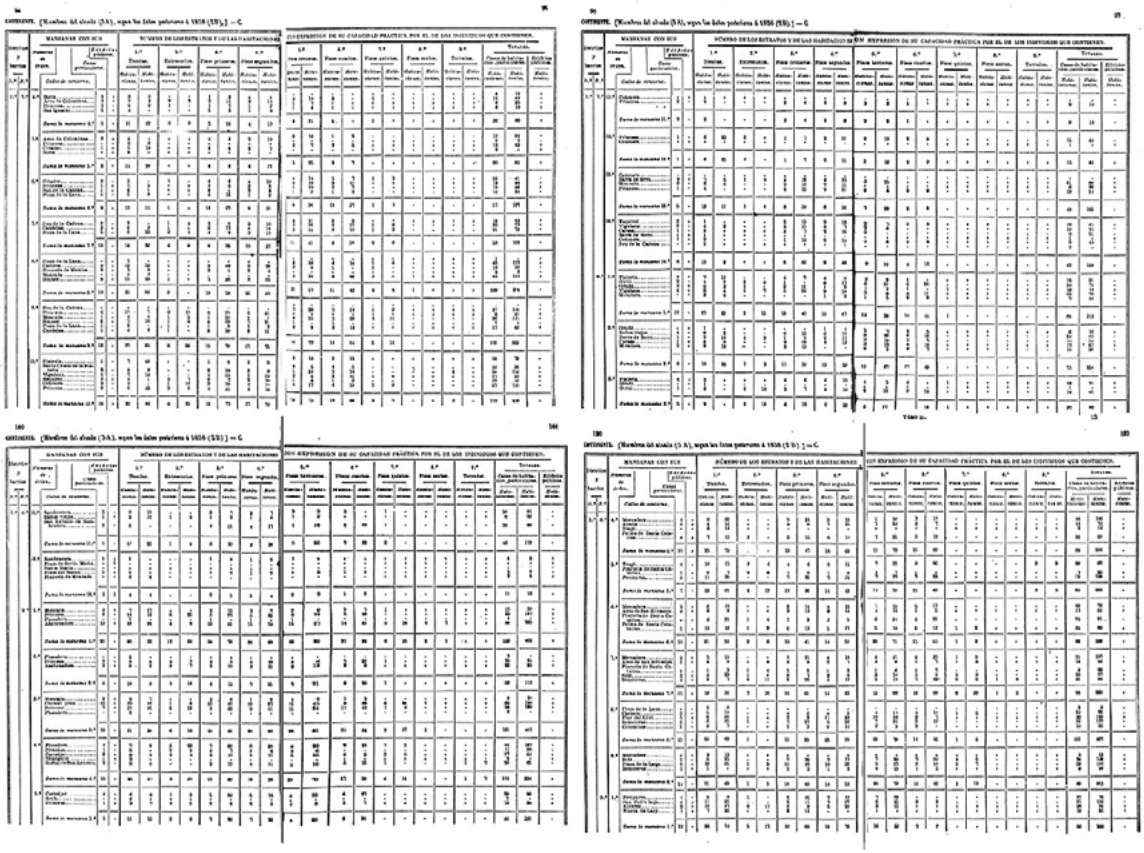
The importance of data and statistics as the foundation for a new disciplinary paradigm is clearly found in Cerdà's major work, where he dedicated the 700 pages of the second volume of his *teoría* to lay down a comprehensive compendium of urban statistics in relation to the materiality of the city but also regarding demographics, health, weather, economy and labour conditions.

Strikingly ahead of his times, Cerdà envisioned a multifaceted urban space that would merge information and matter, society and governance, biology and geography, thus giving birth to a new episteme for an epoch undergoing a technological revolution: "Science and art with their marvellous achievements have conquered nature and obliterated distance, giving locomotion the speed of the wind, and news transmission that of lightning" (Cerdà 1991, 37).

In light of recent developments in computation and software, Antoine Picon discusses the change in the conception of matter with which digital fabrication may engage, after the new understandings that the "new materialism" has put on the table: "instead of framing the universe, computation becomes rather the inner principle of animation, the very life of the material world" (Picon 2019). These words have an echo with Cerdà's interest in the city as an animated organism. When conducting the etymological research with which he initiated the writing of his theory, he soon discarded the word city because of its association with the materiality of the built environment, in favour of urbe that, together with the material, would also include the administrative and the social aspects. This interest in a multilayered understanding of the city steered his study of urbanisation as a process:

"my purpose was not to express this materiality [of cities], but rather the manner and system that these groups follow in forming, and how all the elements that constitute them are organised and then function. That is to say, that in addition to materiality, I needed to express the organism, the life, if I may call it such, which animates the material part" (1867, 29).

At present, when authors like Donna Haraway (1991) and Bruno Latour (1993) have shown us that nature, technology and society are folding into each other,



Sample of statistical charts regarding the built environment, economics, demographics and working conditions in Barcelona occupying most of the 700 pages of volume II of Ildefons Cerdà's *General Theory of Urbanisation*.

the work of Cerdà can be regarded as visionary inasmuch as it did anticipate the entanglement of the environment-worlds we live in today.[5]

4. Digital technologies and the environment

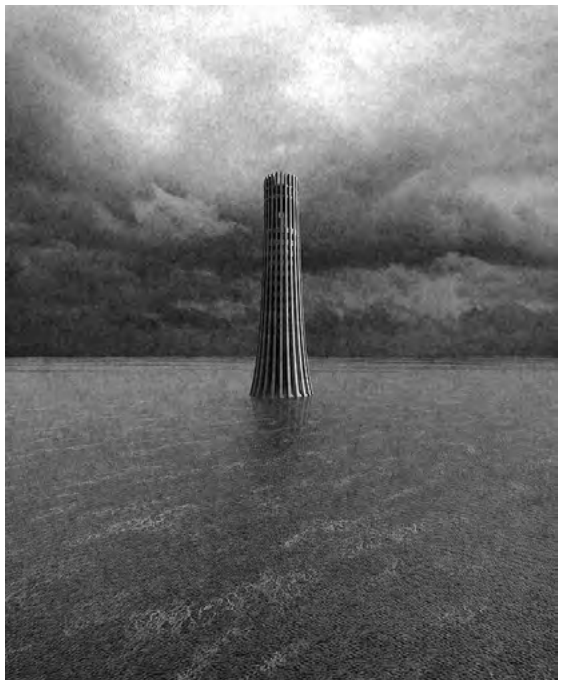
For Cerdà, the natural environment is conceptually reframed as an urban environment, as it is considered an integral part of a much larger universal system. As Ross Exo Adams has pointed out in his thoughtful study of Cerdà, "the urban – both a space and a process – was an order created to totalise the universality of the state by incrementally urbanising its territory" (2019, 131). The famous expression "ruralise the urban: urbanise the rural … *replete terram*", appearing in the frontispiece of the first volume of Cerdà's treatise, stated from the very first page a new understanding of the relation between the city and the countryside; that is, between architecture and nature. If the city was a space constituted in opposition to nature, the urban integrates nature in its constitutive whole, in other words, it becomes a nature itself.

5 The term environment-world is borrowed from Hélène Frichot's book *Creative Ecologies: Theorizing the Practice of Architecture* (2018).

Levelling of the ground and urbanisation of the Gran Via of Barcelona, according to Cerdà's expansion plan for the city. Special commission of the Eixample, author unknown, Barcelona City Archive, 1928.

In a sort of emancipation of the material, digital technologies are nowadays being branded as non-polluting and promoted as agents of a new societal paradigm leading towards a sustainable green economy. Countless emails continue to land on our mailboxes with the eco-paternalistic signature: *Don't print! Save the environment!*, attempting to make us believe that wireless and paperless communication are at the forefront of a new model for a sustainable development. However, this belief in the internet as a clean technology cynically ignores the material reality that sustains it: the environmental cost derived from the production of electronic devices, the energy required for its operation and the subsequent waste generated. The Life Cycle Assessment, an analytical method used in the evaluation of the ecological footprint of building materials and components, is also being applied in the digital realm with not very optimistic results. As Belkhir and Elmeligi demonstrate in a recent in-depth assessment of ICT global emissions, "as our reliance on ICT devices and services grows rapidly, so does our need for energy to manufacture and electricity to power these devices" (2018).

We are commonly aware that as a result of a planetary urban system, the aviation sector is nowadays responsible for 2% of annual global emissions and one of the fastest growing pollutants, a fair concern that should be definitely considered in the future of mobility patterns, policies and technologies. Surprisingly, the ICT sector – digital technologies of information and communication – accounts for 3% of the global carbon footprint and the prognosis for 2040 rises to an alarming 14%, half of the emissions of the whole transportation sector. Out of this 3%, half of it (45%) corresponds to the energy required to keep in



Chang Hyun Ahn, *Monument to the Anthropocene*, Studio 8 Infrastructural Love, Spring 2019, Royal Institute of Technology (KTH). The design studio investigated new and renovated infrastructures across scales as a way of responding to contemporary environmental and social crises, and was led by Hélène Frichot, Sepideh Karami, Adrià Carbonell and Hannes Frykholm.

continuous operation the ICT Data Centres, containers and archivers of the permanent inflow of data persistently generated worldwide (Belkhir and Elmeligi 2018). Digital technologies are also responsible for the huge rise in the extractive industries to source the metals required to produce processors, batteries or built-in cameras and electronic devices, such as copper, lithium, nickel or cobalt, in many cases entailing exploitative labour practices, as Vijay Kolinjivady has recently warned: "Let us take the information economy's dependence on technology as an example. In their work, the creative classes both use and rely on the mass consumption of certain technological products, whose raw materials are extracted in war-torn places like the Democratic Republic of Congo and later assembled in places like China, where workers face precarious working conditions and inadequate pay" (2019).

Besides the embedded ecological footprint of electronic devices, a growing concern is the afterlife of these products. The fast developments in both software and hardware together with an economic model based on immediacy and full access to commodities contribute to the short endurance and lifespan of many of these devices. Smartphones start to be used as almost disposable items with an average of two years life cycle, ready to be replaced as soon as a new model is launched onto the market, with a ridiculous recycling ratio of 1% (Belkhir 2018). Obsolescence is leading to an ever-growing geography of e-waste. In her book Digital Rubbish, Jennifer Gabrys has traced a picture of the growing geographies of electronic trash, and has shown how digital waste is "not a by-product of the manufacturing process, but the dead product headed for disposal" (2011), entering a global market of waste trade.

What are the limits of the production and archiving of big data remains an unaddressed question. However, the impact that these processes of collecting, processing and storing have in our environment-worlds, however densely built or extensively urbanised, should clearly be the object of our attention.

5. Conclusion

Big data and the digital space of the contemporary metric culture also live through physical bodies and matter: the colossal amount of information produced, stored and processed as we speak is being housed in massive solid containers operating on an unaffordable demand for energy and natural resources. Moreover, as extensive research is by now showing, so-called clean technologies often involve dirty production. The digital economy is currently mineralising the air, inasmuch as it digs the mines in search for rare materials that sustain our wireless transmissions. The stress that digitisation has exerted on space is multiscalar, and it goes from planetary networks and wired territories, to a global system of transport and logistics, to remote sites of extraction, to the remaking of urban centres and the urbanisation of the human body.

If Antoine Picon points to the "lack of clearly defined political and social agenda" in contemporary architecture when discussing questions of virtuality and immateriality in digital architecture (2004), we could equally apply such concerns to the urban field. In a context of great need for theory in urban practice and of political agenda in urban design, we may draw on the lessons learned from Cerdà, the urban theorist but also the urban planner. What might be needed is that contemporary urban science, which should include both theory and practice, engages again in the administrative, the political, and the social in conjunction with the material, thus relaunching the discipline of urban planning and design to meet the great complexities of contemporary urbanisation.

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Adrià Carbonell

is an architect and urban designer. He is a lecturer at the Royal Institute of Technology (KTH) in Stockholm, and has previously held teaching positions at KU Leuven, Umeå University and the American University of Sharjah. He is also founder of the research platform Aside, where he writes on the relationships between architecture, urbanism and geography. His writings have been published in Zarch Journal of Interdisciplinary Studies in Architecture and Urbanism, San Rocco, MONU and Cartha, among others.

MODULATED MODULARITY: FROM MASS CUSTOMISATION TO CUSTOM MASS PRODUCTION

Siim Tuksam
Estonian Academy of Arts,
Faculty of Architecture [1]

Abstract

The idea of mass customisation is as old as digital technologies and computer aided manufacturing – as is the idea that consequently our environment could also be tailored to 'individuals' needs. Subscribing to that ideology, digital architecture has up until recently relied on the fabrication of an abundance of unique elements. Testing these ideas in industrial manufacture though has still proved problematic. Early digital architecture did not change construction, rather through automation it could merely put more effort into producing more extravagant forms, often ending up creating a logistical nightmare.

Designers of the second digital turn are trying to overcome the discrepancy between construction methods and algorithmic design that is pursuing heterogeneity, sustainability, democratisation of construction, and so on. Automation depends on standardisation rather than endless variation. Towards such ends, a much better suited approach rather than mass customisation, could be custom mass production. Using contemporary means of production, the standardised modules can be a lot more complex than their modernist predecessors and have a lot more intelligence embedded in them.

My research looks at dynamic geometric systems of modulation that depend on realities of production and produce architectural effects. The approach I have developed for subdividing volume (mass, surface, lattice) is modulated modularity. The term suggests an algorithmic play on or rigorous modification of modularity. The classical tool of modularisation has been the grid – a static array of axes. Algorithmic means of design allow us to look at the grid not just as a less constrained periodic subdivision of space but as a design tool that is dynamic, adaptable and allows for subjective intervention.

Modulation, a term most often connected to music, also raises questions of proportion, rhythm and the relationship to the human body in architecture. This in turn could be considered another reasoning for digital architecture to turn from the continuity of calculus to the granularity of data. Modern architecture has often been criticised for the lack of the human scale. The new rise in discrete tectonics, connected to automation of assembly, could also be a return of human scale. Rhythm is the discretisation of our environment in space and time. Just as we discretise sounds that we make into syllables to manage the noise of the signal, we are dividing our environment into comparable parts to understand and communicate. Proportion and rhythm therefore are tools for making our environment relatable.

1 Correspondence: siim.tuksam@artun.ee

Using algorithmic design we are bound to be a lot more precise about following the regulating lines of our automated designs. This in turn will create an opportunity for the emergence of the other. We are able to set up simple algorithms – rulesets that define relationships within our designs – that then start to govern the design space. In addition, we can set parameters inside those governing algorithms that can be changed on the go, based on qualitative or quantitative feedback, creating the potential for the subjective manipulation of these automated processes, which creates a duality of human-nonhuman interaction.

This paper looks at three main aspects of my creative work. First, it is situated within the context of algorithmic design due to its dependence on rule-based automation in design, fabrication and assembly, and more importantly, its fascination with emergence and the other. Second, the work is conditioned by industrial fabrication and a non-speculative approach to construction; therefore, depending on an analysis of the current affordances of the real. Third, the emergent language of modulation has historical precedents in proportion, rhythm and architecture's relation to *the body*.

Keywords: algorithmic architecture, automation, digital architecture, fabrication, modular architecture

1. Introduction

With the rise of digital technology over the last 30 years and the promise of individual liberation by it, it seemed a fully democratic completely individualised society is about to emerge. A few decades later, we are seeing how big data actually makes us predictable and manipulatable and has created stronger hierarchies of power, as most prominently evidenced by the Cambridge Analytica scandal. Yes, we are more individualistic than ever, but we are also more connected than ever, meaning statistically we are all classifiable datasets for machine learning algorithms. Considering this, is the digital really an enabler of endless variation, as proposed by the first generation of digital architects, or rather a contingent system of standardisation?

2. Conditioning circumstances

How is variation created in the manufacture of digital designs? Digital colour printers produce endless variety, but on the basis of very strict standardisation – by placing dots of three specific colours onto paper. It is the same with screens – an array of three colour pixels that light up with different intensities. The same technology has been applied to building facades of lower resolutions. While in some of the more successful designs, the pixel itself has become an architectural detail.

Pixelisation, or rather voxelisation, can be used to create a similar level of the automated modularisation of form. So that leaves us with the question, what is

a good 3-dimensional pixel or module in construction? I would argue there are two main somewhat contradictory parameters at play here – efficiency vs flexibility, or rather resolution in this context. A lower resolution results in fewer elements but also fewer possibilities for spatial articulation.

If we look at the way construction elements and modules are designed, they are mainly optimised for the logistics of mechanical fabrication, transport and manual construction, not necessarily architectural flexibility. Custom or rather computer aided mass production allows us to rethink some of these parameters in favour of higher degrees of freedom.

Still, automated fabrication today is more reliable in repetition. It is easy to automate the production of almost any detail to be produced in bulk. Producing a unique part every time remains inefficient and has a high margin of error. Not to mention the only zero-waste approach to creating nonstandard elements is additive manufacturing, where the margin of error is also the highest. Through the projects that we have done with PART and our experience talking to engineers in industry and working on large scale non-standard projects, the most viable way of producing elements is machining standard stock materials, mostly cutting and milling. This means stock waste is also an issue.

These practical constraints can be seen as the conditioning circumstances of the modulated modularity method. It is based on a repetitive algorithmic subdivision, where the resulting elements can be evaluated for material efficiency. Building on top of this, structural analysis and optimisation can be used to

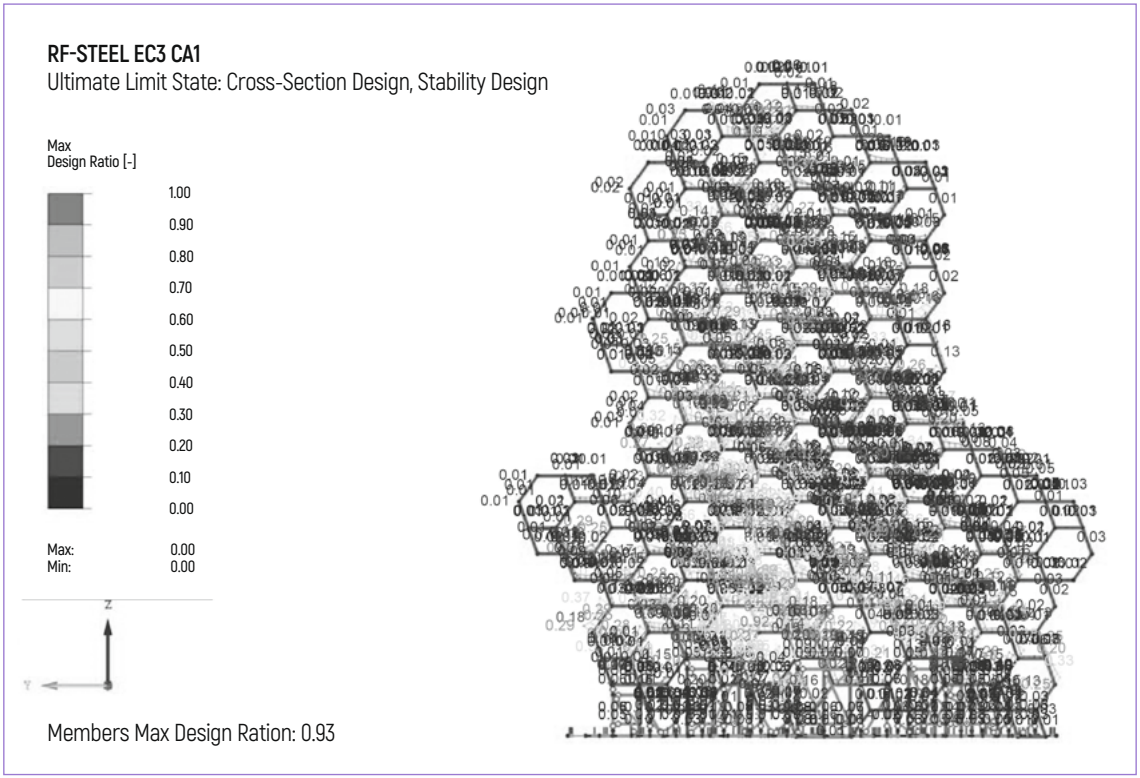

Figure 1. Structural analysis for PART's Urban Jungle project by Bollinger+Grohmann Engineers.

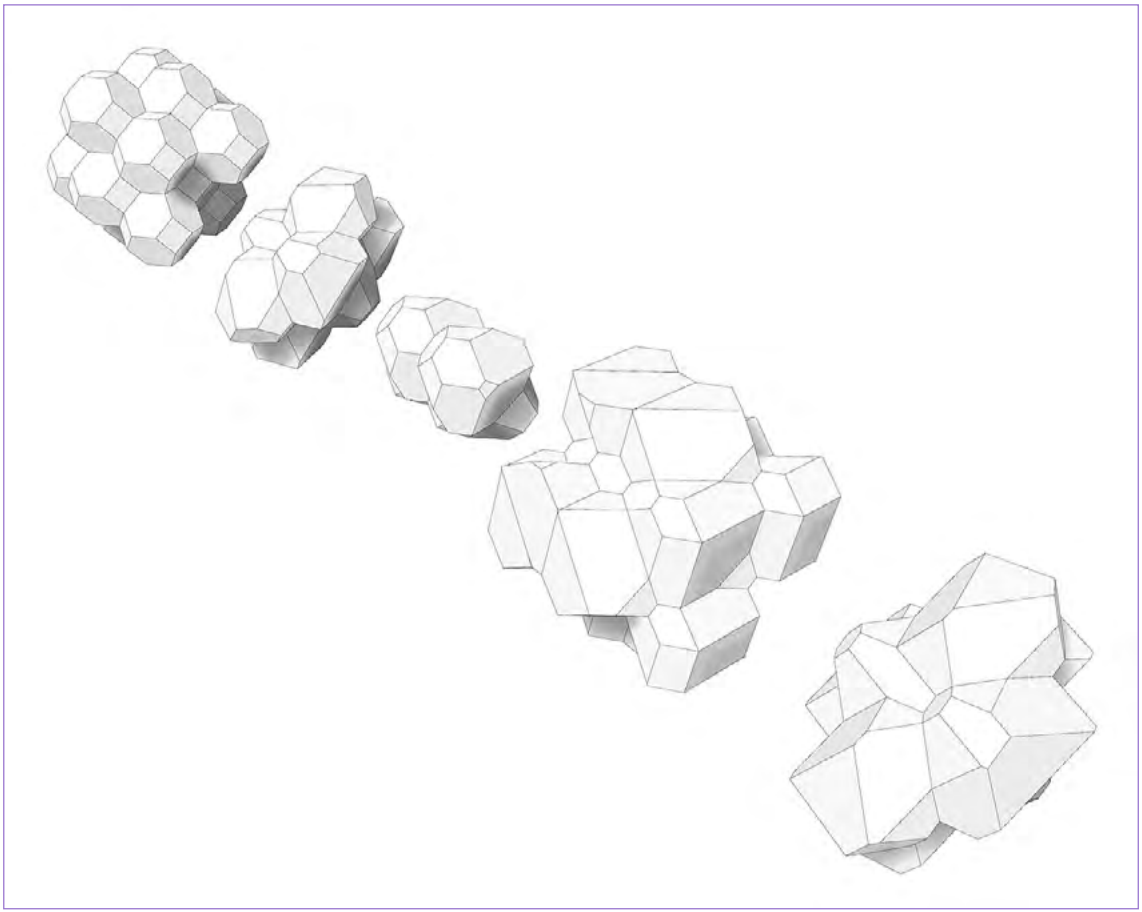

Figure 2. Variations on periodic Voronoi cells.

determine the materiality and placement of these elements (Fig. 1). All of these practicalities form 'the reality' that is built into a virtual model to define the modulation of form.

3. Algorithmic play

The term modulated modularity suggests an algorithmic play on or rigorous modification of modularity. The classical tool for modularisation has been the grid. Due to mechanical production and the way architecture is conceived using two dimensional drawings, the grid has typically been a projection of parallel axes. Algorithmic means of design allow us to look at the grid not just as a less constrained periodic subdivision of space but as a design tool that is adaptable, based on 'the real' and allows for both evolutionary optimisation and subjective intervention (Fig. 2).

Looking at the term modulation in philosophy, Gilbert Simondon and Gilles Deleuze give another useful meaning for it. Simondon's definition of modulation associates form and matter with the example of brick moulding, where the form is not a direct imprint of the mould but rather the result of all the forces in the clay and the mould finding an equilibrium (Bernier-Lavigne 2015). Deleuze, on the other hand, notes a shift in societal control from "'moulding' to 'modulation', namely from a form-imposing mode to a self-regulating mode" (Hui 2015, 74).

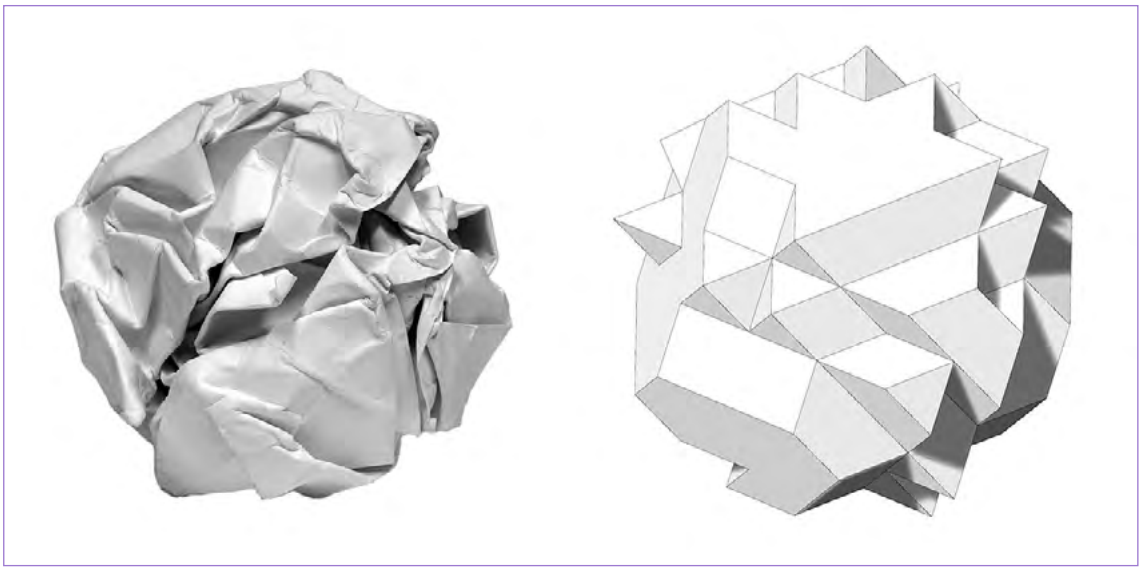

Figure 3. Material vs algorithmic modulation.

Bringing this kind of modulation to algorithmic architectural design creates another layer in this process. Not only is form modulated by actual forces and its materiality, but also by the designed algorithmic model that governs these relationships, where the objective and subjective aspects become blurred (Fig. 3). Modulation, in this context, is therefore not a strictly self-organising system but a designed system with partially self-organising characteristics.

This dynamic play with geometry also has a relationship to simulation. When we simulate physical forces on the screen, we get a certain idea of how a structure might behave. This might be one reason why people are watching videos of soap being cut on Instagram or use apps to manipulate simulated slime (Fig. 4). Something similar happens with dynamic geometric systems – we get a feeling for the geometry almost like a new materiality, or rather formality. The fascination with the developed method of modulation does not really lay in the efficiency of combining constraints of fabrication and construction but rather developing a behavioural system which reveals a certain emergent formality (Fig. 5).

Figure 4. Brain orgasms from simulations.

Negotiating contradictory goals is where algorithmic design creates the most interesting results – 'the other', the strange, the unexpected. To borrow words from Manuel DeLanda "the virtual is manifested in those situations where intensive differences are not

Figure 5. Recent projects by PART, clockwise from left: Pärnu Art Hall, competition entry; car park in Tartu, competition entry; Shift Lofts in Tallinn, schematic design.

cancelled out" (DeLanda 2002, 64). In Deleuzian terms it is the actualisation of the virtual that creates the fascination in algorithmic design. In PART's designs, we are using this method of modulation so as to reveal the designed virtual model through the process – exploring the effects of the negotiation between the 'mould' and the 'clay' so to say.

4. Modulation and the body

Modulation is most often connected to music and also raises questions of rhythm, proportion and the relation to the human body in architecture. This in turn could be considered another reasoning for why digital architecture should turn from the continuity of calculus to the granularity of data. Modern architecture has often been criticised for the lack of a human scale. The new rise in discrete tectonics, arguably connected to the automation of assembly (Picon 2010, 166), could also be considered a return of the human scale.

Rhythm is the discretisation of our environment in space and time. Just as we discretise sounds that we make into syllables to manage the noise of the signal, we are dividing our environment into comparable parts to understand and communicate it (Dennet 2017). Proportion and rhythm, therefore, are tools for making our environment relatable. Not forgetting, edge detection is essential for machine vision – differentiation is necessary.

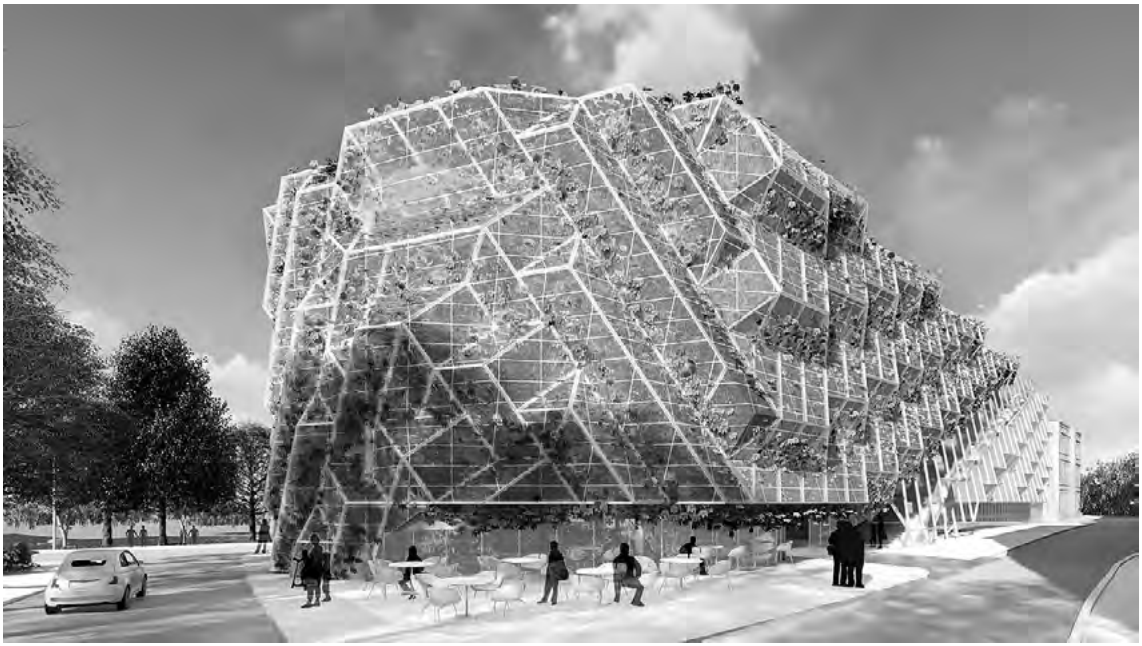

Figure 6. Car park in Tartu, competition entry.

Algorithmic regulating lines operate in a different way to those drawn on classical or modernist elevations. Periodic spatial subdivisions reveal how the design surface (e.g. the massing) relates to it (Fig. 6). Just like isometric lines on topographical maps reveal the undulations of the landscape, modulation emphasises the geometry of the form that it is imposed on. Like the imperfections of the brick coming out of the mould, the modulated surfaces reveal the underlying 'forces' at play in their conception – creating patterns that can be interpreted.

5. Conclusion

In using algorithmic tools, we are bound to be a lot more precise about following the regulating lines of our automated designs. We are able to set up simple algorithms – rulesets that define relationships within our designs – that then start to govern the design space. Not only that, we can also set parameters inside those governing algorithms that can be changed on the go, based on qualitative or quantitative feedback, creating the possibility for the subjective manipulation of these automated processes. This creates a duality of human-nonhuman interaction – the rational and 'the other'. The insertion of subjective judgement into the algorithmic model creates greater control of the modulated formal outcome and its reading. The scale of elements or the resolution of the form can be manipulated on the go, creating varying intensities of modulation in relation to the human body and its experience of the space.

This paper looked at three main aspects of my creative work. First, the work is conditioned by industrial fabrication and a non-speculative approach to construction; therefore, depending on an analysis of the current capabilities and the conditioning circumstances – 'the real' (Picon 2010, 212). Second, it is situated within algorithmic design discourse due to its dependence on rule-based automation in design, fabrication and assembly, and more importantly, its fascination with the emergence of 'the other' in designed virtual systems. Third, the emergent language of

Figure 7. Projects by PART, left to right: Body Building Installation 2015, Urban Jungle 2018, Shift Lofts 2019.

modulation relates to a long tradition of proportion and rhythm to emphasise architecture's relation to the human body. This process of experimentation has evolved from non-standard designs based on mass customisation, toward modulated modularity based on custom mass production (Fig. 7).

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Siim Tuksam

is an architect, founder of PART – Practice for Architecture, Research and Theory. He has an M.Arch. with distinction from University of Applied Arts Vienna, Studio Greg Lynn, and has gained experience at the Southern California Institute of Architecture and a number of architecture and design offices. He studies the opportunities, tendencies and impact of algorithmic design and automation in architecture. He has been exhibited in numerous exhibitions and was curator of Interspace, the Estonian exhibition at the 14th Venice Biennale of Architecture Exhibition and TAB 2015 main exhibition 'Body Building'. He was creator of the Tallinn Architecture Biennale Installation Programme and 2015–2018 curator of the Open Lecture Series. Tuksam is currently a PhD candidate, junior researcher and lecturer at the Estonian Academy of Arts, Faculty of Architecture.

HOW NEW TECHNOLOGIES CAN PROMOTE THE REINTRODUCTION OF TRADITIONAL KNOWLEDGE IN THE PROFESSION OF A CARPENTER

Wolfgang Schwarzmann
Institute of Architecture and Planning,
University of Liechtenstein

Abstract

The ongoing transformation process driven by industry 4.0, will affect almost each and every thing in our environment. This change may take several decades; however, already today an impact on the daily work of a carpenter can be observed.

In Central Europe, new CNC robots are installed in many carpentry workshops. These machines provide quality and productivity using the current state-of-the-art technology. Emerging from this technological change, benefits to production according to speed, precision and reliability can be expected. Besides these advantages, a process of transformation with regard to knowledge and tradition will occur that can be understood as the beginning of a radical transformation. Embedded in the theoretical foundation of Actor-Network Theory (ANT), the profession of a carpenter has to be interpreted as being part of a constantly shifting network of relationships. Based on this social theory, it is possible to interpret the technological change as a new driving force, which changes the perspective of this profession. In this paper we compare two case studies from different centuries. By taking a closer look at the manufacturing process of a 'zig-zag' joint, old and new techniques are compared and evaluated, focusing on the integration of a CNC-joinery machine. Only by making use of these new technological solutions was an economic reintroduction of this 'zig-zag' joint possible. Furthermore, the successful adaption of this joint was only possible because the carpenter could provide specific knowledge, crucial for programming the robot and later assembling the material. Technology will make a carpenter faster and more cost-efficient, but without doubt, the core elements of his profession will be affected by the change. This research will promote further discussion for future developments in how digital technologies and physical production might act together.

Keywords: carpenter, Industry 4.0, digital transformation, tradition, handcraft, actor-network theory

1. Introduction

In Central Europe, the costs of erecting a building were constantly rising in recent decades. For example, in Germany, wooden components produced by a carpenter increased by 2.7% between August 2018 and August 2019 (Statistisches Bundesamt 2019, 8). Since the end of this development is not possible to predict, industry is forced to find new solutions for how to deal with these rising costs. One approach to lowering these increasing prices is a reduction of manual labour by shifting to automatic solutions. Nowadays, these technological solutions are already

common in the car industry but might be surprisingly new in manual labour jobs like carpentry.

The profession of a carpenter can rely on a rich and long history. This job was always been in a close and direct relationship to the processed material. In recent years, more and more workshops have started to invest in CNC-joinery machines. By implementing these new technologies in existing structures, former processes start to shift. The presence of a CNC-joinery machine certainly changes the relationship between a carpenter and the processed material. In this paper, we are going to make a comparison that will examine how this shift in the structures can lead to new possibilities in the profession of a carpenter.

2. Background

2.1 The profession of a carpenter

The profession of a carpenter can be described as being an expert on structural wood constructions. In comparison to a joiner, whose daily work focuses more on interior elements like doors, windows and furniture, the carpenter is responsible for all kinds of loadbearing wooden parts of a building. These parts are mostly of a larger scale and weight, leading to the frequent use of machines like a crane, a forklift and other tools for reducing physical workload (Herres 2016, 38).

2.2 The profile of a CNC-joinery machine

A CNC-joinery machine is a computerised machine-centre with a variety of different manipulation tools. In comparison to a band saw or a circular saw, the machine itself can conduct all kinds of operations relating to the processing of materials. While most of 'traditional' electric tools need a skilled carpenter to guide the machine by hand, a CNC-joinery machine can conduct almost all tasks autonomically (Schindler 2009, 194). These processes are under the supervision of a machine operator. A huge advantage in comparison to manual work is the significant increase in terms of issues like processing time and accuracy of editing. Even though the job-specific programming of the CNC-joinery machine will claim some time, the process as a whole can show a number of economic benefits (mikado n.d.).

Since the early 1980s, machine-suppliers were able to deliver robots that could handle numerous manual tasks normally performed by a carpenter. With more than 5,000 globally shipped machines so far, the self-claimed world market leader for CNC-joinery machines Hans Hundegger AG can prove the high acceptance of their products (Hans Hundegger AG n.d.). These machines are constructed in close collaboration with the end users. The company can be seen as the general contractor in the case of engineering, constructing, installing and implementing a new machine in an existing workshop (Hans Hundegger AG n.d.). Furthermore, they offer a 24-hour hotline service to support local carpenters whenever hardware or software-based problems emerge. Therefore, industry not only targets the goals a carpenter might address, but already has already been meeting their needs for almost 30 years.

2.3 Industry 4.0, in the environment of a carpenter?

The previous description of what a carpenter might require and what a CNC-joinery machine might be capable of, leads to the question of how these two issues accompany topics like industry 4.0. On closer inspection of the solutions that might be available, investigations revealed that software companies already provide solutions to integrate a CNC-joinery machine in the world of the IoT (Internet of Things). Solutions like the platform 'tapio.one' provide services like real-time machine monitoring, material-flow-optimisation or machine-supporting cloud-backups. These applications can be implemented into an existing structure and are later accessed via a smartphone or tablet (Volm and Neumann, n.d.).

The ongoing transformation of processes relating to Industry 4.0 will not only affect single tasks but soon change the whole business process of a company (Vollmer et al. 2017, 44). Even though experts are unsure about when and how this transformation will substitute jobs, there is general agreement on the significant reduction of repetitive tasks (Vollmer et al. 2017, 61). This paper will take a closer look at what kinds of teamwork the new technologies and traditional knowledge might promote.

3. Methodology

In this research, our approach was to describe how technology can reintroduce knowledge, anchored in traditional ways of manufacturing. Two case studies, each from another period in history, are compared in terms of construction and fabrication techniques. This paper focuses on the application of one specific wooden joint, later described as the 'zig-zag' joint. Due to the infrequent occurrence of this joint over recent decades, its recent reappearance has to be seen as a remarkable phenomenon.

3.1 Actor-Network Theory applied to the profession of a carpenter

'The machine is not only a tool, it's more like a partner' (Belliger and Krieger 2006, 15). This quote already reveals fundamental points of 'Actor-Network Theory' (ANT). Following its line of argumentation, it is not possible to draw a strict separation between technology and society. According to Belliger and Krieger (2006), recent developments including *virtual reality, artificial intelligence* and *the process of digitisation*, further promote the blurring between humans and technology. They prefer to use the term 'Actants' (introduced by Bruno Latour) for human and non-human objects (Belliger and Krieger 2006, 15), in a constant process of alteration and movement.

In our research, the profession of a carpenter has to be seen as a node in a constantly changing network, the parameters of which might be culture, geography, nationality, or in our case, new technologies. In this study, we take a closer look at how the interwoven profession of the carpenter might have been influenced due to the new presence of the CNC-joinery machine.

3.2 Two case studies

To provide a better understanding of where this new emerging 'hybrid knowledge' might appear, an example shall be given. In the following sub-section, a comparison is made of two different wooden construction details. The first is a wooden composite beam from 1740 (Fig. 2). The 270-year-old beam was part of a research project and had to be replaced by a new fabricated one (Rug et al. 2012, 29). In 1740, solutions for spanning wide spaces were limited. Whenever possible, craftspeople made use of timber framing. In this case, even more structural strength was needed. As can be seen in the image (Fig. 1), two horizontal beams of wood were stacked directly on top of each other. To further raise their bearing capacity, the flanking planes were interlocked using a specific 'zig-zag' cut. This rare and challenging wooden connection had to be manufactured with the highest possible precision. Only if all the wooden teeth interlocked perfectly, could the static effect be achieved. To secure the pieces in their position, threaded bolts were installed. Their primary function was to keep the wooden parts in place (Fig. 1).

Over time, technologies like glue-laminated wood could evolve. These new wooden materials significantly cut the need for manual labour. New production techniques made it possible to deliver custom-made chunks of wood of the right size, quality and strength for each application. The labour-intensive and hard to manufacture interlocking 'zig-zag' shape became obsolete (Rug et al. 2012, 26).

This leads us to the second case study. For a number of years, industry has been able to mass-produce glulam from beech. Thin layers of veneer are peeled from beech wood and pressed into almost any shape needed (Pollmeier n.d.). Due to its high density as a hardwood, beech can handle a broad spectrum of challenging structural applications. When constructing with wood, one fundamental challenge is where columns and beams meet at one point.

In 2019, the Office 'Hermann Kaufmann + Partner' designed a production building for the SWG Produktion Schraubenwerk Gaisbach GmbH (Jacob-Freitag n.d.). SWG is a company well-known for manufacturing high quality screws. The roof is constructed as a wooden framework made from beech glulam (SWG 2019). The common approach to structures like these is to connect wooden sticks with custom-made steel knots. In this project, the client SWG demanded a reduction of structural steel parts. This requirement forced the carpenter to work out an alternative approach to the joints in the wooden framework.

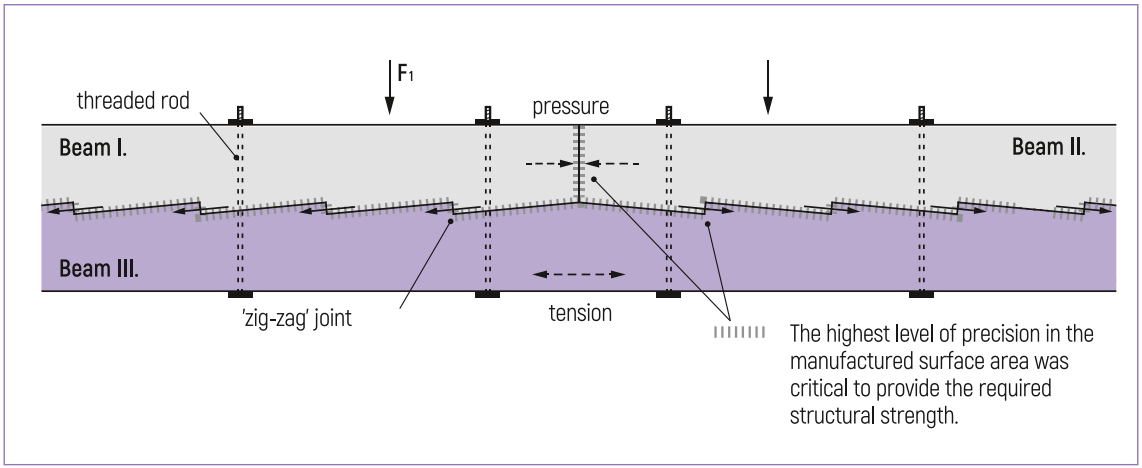

Fig. 1: Characteristics of the described traditional 'zig-zag' joint.

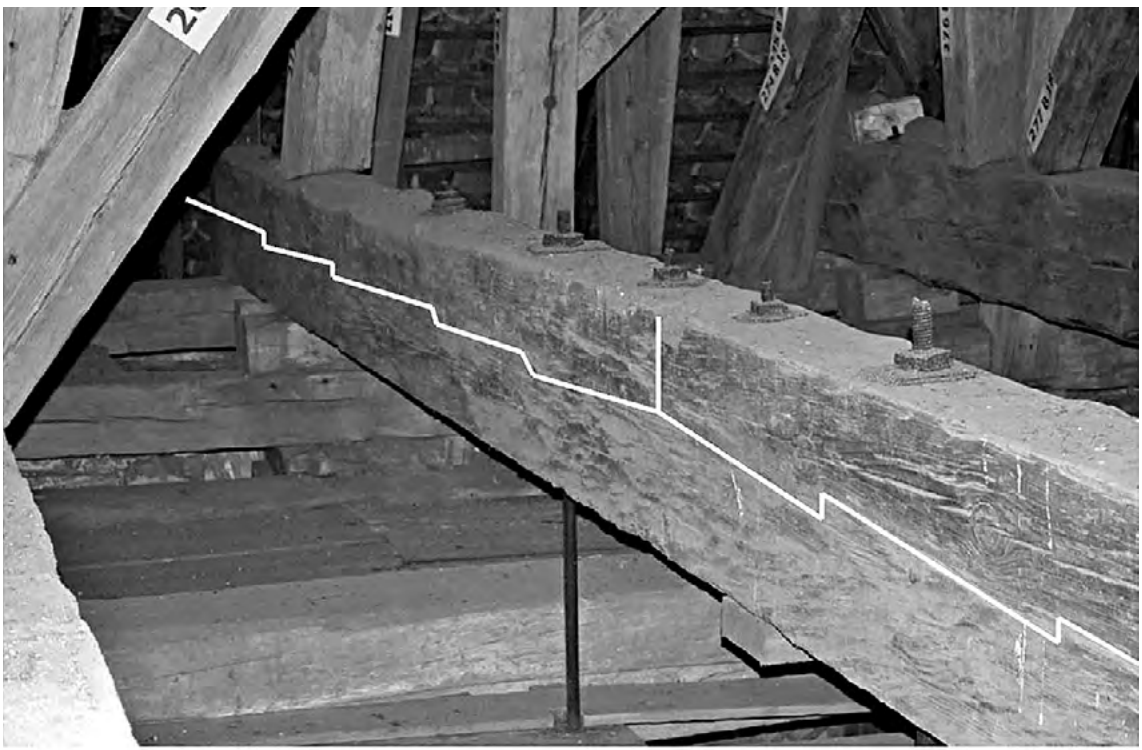

Fig. 2: Original composite beam from 1740 (Rug et al. 2012, 29).

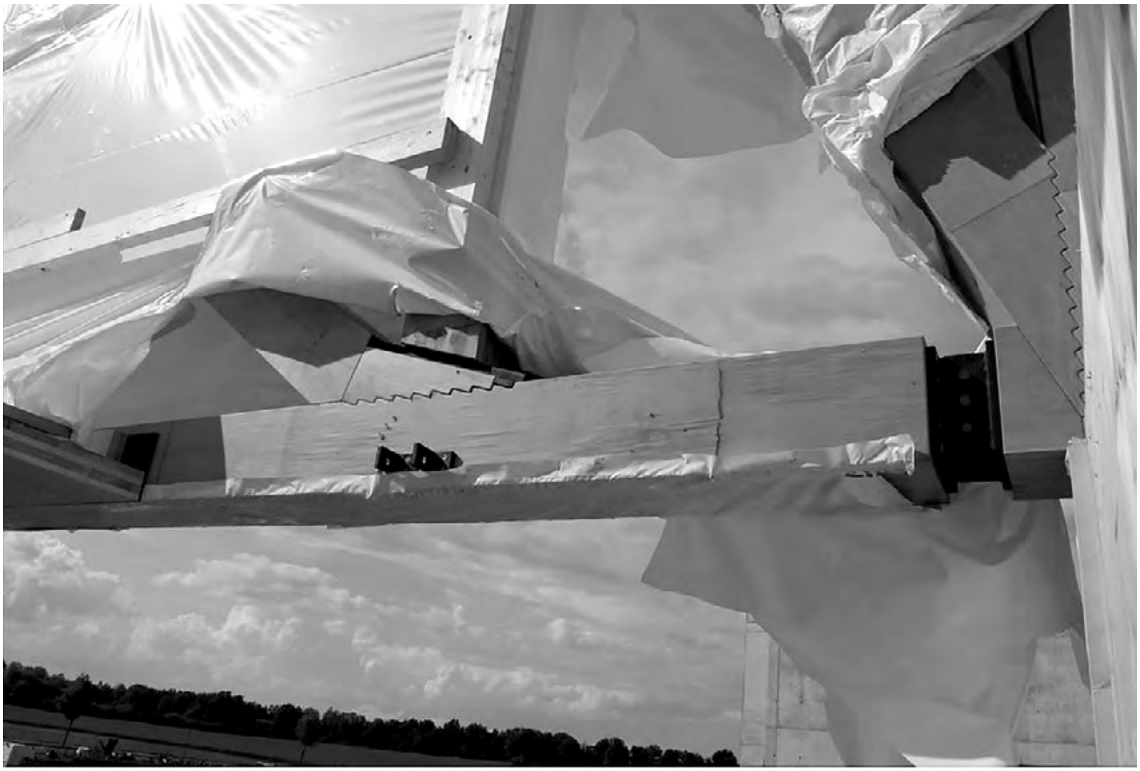

Fig. 3: Timber frame knot with 'zig-zag' joint (Hermann Kaufmann + Partner ZT GmbH n.d.).

As can be seen in Fig. 3, their solution involved the integration of a 'zig-zag' shaped interlocking design. At some points, screws were needed to secure the wooden components in position. Only when unavoidable, additional steel parts were introduced. Structural and loadbearing functions are almost completely fulfilled by wooden parts.

In a personal interview, the carpenter confirmed that all the wooden processing operations in relation to the 'zig-zag' shape could be performed by their CNC-joinery machine. Furthermore, he mentioned that the milling tasks were carried out using a conventional milling head, normally used for cutting grooves.

3.3 Comparing the two case studies

Characteristics of the historic 'zig-zag' joint (1740):

(++) At that time one of the most suitable solutions for increasing the structural performance of wooden components (Rug et al. 2012, 26)
(+) all parts are easy demountable (reuse, recycling, replacing broken parts etc.)
(o) few metal pieces needed (nuts and bolts for securing the wood in position)
(-) very labour-intensive (multiple steps involving marking, cutting and chiselling)
(-) high precision needed (only skilled carpenter can perform this work)

Characteristics of contemporary 'zig-zag' joint (2019):

(++) CNC-joinery machine able to handle precision and speed in manageable amount of time
(+) overall reduction of steel parts in the framework
(o) knowledge of skilled carpenter for proper implementation of CNC-tool needed
(o) few metal-pieces needed (screws for securing the wood in position)
(-) only suitable for specific applications
(-) still more expensive (time, funds, manufacturing e.g.) than ordering a standard steel-piece

4. Results

When comparing these two case studies, it can be said that the motivation for manufacturing a 'composite beam' in 1740, is different than it might be for the recently erected SWG building. Over time, the manufacturing technique has changed dramatically when we compare the labour-intensive manual work and the machine-aided milling process. New technologies promote the frequent application of glue-laminated wood, and therefore eliminate the manual production of time-consuming operations, such as the 'zig-zag' joint. However, solutions for structural challenges are still an important issue to resolve. Although issues like wide spans can now be solved on a material basis; a robot might not substitute the creative new-combination of expert knowledge. Even though the motivation and background for these two applications emerge from different incentives, the implementation of this wooden joint did provide a suitable solution in both cases.

If we assume that in the first case study, the carpenter was using an axe or a saw as his most frequently used tool, it can be said that in the second case study, the contemporary carpenter mostly relied on the capabilities of his CNC-joinery machine. Following the argumentation of Schindler (2009, 223), the profession of a carpenter always evolved with the technological steps relevant in the surrounding society. These craftspeople are both making use of specific contemporary tools, common at the time they were working. In both cases, a skilled craftsperson made use of the 'zig-zag' shape. What really marks the unique achievement is the recombination of the knowledge to the tools offered, tailor made for a specific problem. Only the ability of an experienced carpenter can create a perfectly interlocking 'zig-zag' shape. Whether the professional makes use of an axe or a CNC-joinery machine need not be a determining factor in this comparison.

5. Summary and conclusion

In this work, we show how a rare wood joining technique can be re-introduced as a construction system in the 21st century. By comparing a traditional 'zig-zag' joint from 1740, and a contemporary 'zig-zag' joint from a recently erected building, similarities and differences in manufacturing can be illustrated. The first case study shows a traditional 'zig-zag' joint manufactured in 1740. It is the product of a labour-intensive process, where the production needed the knowledge and time of a skilled carpenter. The second case study shows a contemporary 'zig-zag' joint produced in 2019 by a carpenter in Germany. This solution was completely processed using a modern CNC-joinery machine. The labour-intensive processes of measuring, milling, and cutting were handed over to a computer-guided robot. The significant reduction in manufacturing time and cost could make this wooden connection compete with conventional solutions. Besides the fact that the carpenter made frequent use of the machine as the first key resource, his specific knowledge must be seen as the second crucial ingredient that finally led to a successful solution in the final product. As described by the carpenter, his specific knowledge caused him to propose this approach to joining wood with a 'zig-zag' shape, which is unconventional in today's industrial context. Furthermore, his particular programming skills and deep understanding of how to make use of a CNC-joinery machine gave him the ability to translate his expertise into a contemporary application of wood joinery. The cooperation of a skilled human and a programmable robot working together made it possible to find new solutions. Thanks to close cooperation, traditional methods of manufacturing might return to more contemporary applications. It can be argued that the establishment of a new application of 'hybrid knowledge' could be observed. Only if both 'Actants' have a deep

understanding of their opponents' capabilities, might new applications emerge.

This paper focused on the comparison of how a special type of wood join can be interpreted in accordance with contemporary applied fabrication methods. Focus in this case could only be applied to a small part of this described network. Future work will be directed towards a deeper understanding of how the profession of a carpenter is currently influenced by new technologies to explore more recent applications.

Acknowledgements

I want to thank my Professor Urs Meister, along with Professors Dr Anne Brandl and Dr Christoph Michels, who provided expertise that greatly assisted this research.

Furthermore, I would like to thank Professor Dr Sascha Friesike for providing an open ear to the whole research project and in that improving my line of argumentation.

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Wolfgang Schwarzmann

is employed as researcher and enrolled as PhD student at the University of Liechtenstein. After he finished his Architecture studies in Austria, he worked as a carpenter-trainee at a workshop and thereby developed a deep understanding of this specific field. Further on he worked in the architecture office of Prof. Hermann Kaufmann, a well-known Austrian Wood-Construction Architect.

ROBOTIC BRAILLE AND SPATIAL MAPS: COMBINING TACTILE AND VISUAL NARRATIVES

Dagmar Reinhardt,
Povl Filip Sonne-Frederiksen,
Thorlak Solberg
Aarhus School of Architecture

Lea Johanne Sarfelt,
Birgit Christensen,
Mauro Biagi
The Institute for Blind and Partially Sighted (IBOS)

Abstract

Vision and tactility inform our cognition and perception of objects and environments. Yet there exist differentiations as to how perception is processed and formed, depending on unique and personal abilities for sensory cues. For people with low vision or blindness, tactile information processing posits a key approach to engage with and understand spaces, activities and interactions. This competence with tactility provides a rich context for current digital cultural practices that are predominantly informed by the visual, towards informed and complex materiality and space.

The empirical research discussed here explores an understanding of tactility through transfers of images and information, towards surface patterns and textures, and the integration of braille text. In support of tactile literacy for reading and assessing images and letters, the research develops a surface archive of tactile patterns. Scripting code is explored for design variability in terms of points, grids and line configurations and a six-axis ABB robot equipped with different routing tools for milling timber. This surface archive is further extended towards a prototype series of 'hyper-artefacts' — multi-functional furniture objects that integrate different sets of visual or pictorial information that can be 'decoded' by sight, and tactile information to be deciphered by braille experienced readers. By adopting a practice of Universal Design for equitable, simple and inclusive use and by combining tactile and visual narratives for diverse audiences, the research thus contributes to increasing our awareness, knowledge and understanding of other people's conditions, thus supporting positive changes in attitudes and behaviour, towards more inclusive environments.

Keywords: blind, braille, robotic milling, spatial maps

1. Introduction

Our experience of an environment is multisensory, based on continuous information through relationships that are dynamic and mutually influential (Jenkins, Yuen, and Vogtle 2015). Interactions depend largely on a person's unique physical characteristics (such as body, age, size, gender), and on sensory capabilities. People with different sets of abilities (such as the blind and partially sighted) need to decode and choreograph an array of sensory interactions to produce an organised and meaningful understanding and awareness of the space around them, because constructing reliable representations and interacting with objects and environments or participating in activities can be challenging (Marston and Golledge 2004). This is significant, as public environments (spaces, buildings or communal areas) provide a framework for inhabitation, shape individual responses, and establish a cultural setting (Herssens and Heylighen 2012). Here, Universal Design (UD) can contribute to an equal and cohesive society by addressing people with different abilities, for shaping 'hyper-artefacts' that integrate interpretive information within objects for tactile experience (Fuller and Watkins 2010).

In the current context of the digital, this research aims at a democracy of touch, constructing participatory ecologies through a collective individuation through the event of perception beyond the visual domain. By means of adopting advanced CNC manufacturing and robotic fabrication for patterns and chair prototypes as multiples for shaping a public conversation space, the research aims at knowledge of and design for tactile surfaces and hyper-artefacts that provide information and interpretive narratives and are decoded by audiences with different abilities, towards a discourse on integration and inclusion.

This paper reports on collaborative empirical research by the Aarhus School of Architecture and IBOS (National Centre for Blind and Partially Sighted, Copenhagen, Denmark). In the following, section 2 introduces a background on vision and cognition, common uses of tactile and pictorial information and text, and universal design principles. In section 3, the paper discusses methods and workflows from computational scripts and robotic manufacturing towards establishing a pattern archive and adaptation for hyper-artefacts as functional object series with encoded visual, pictorial and textual information. Section 4 offers a discussion on scope, process, surface archive and prototypes, and the article concludes in section 5 by looking to future research trajectories.

2. Cognition, tactility and inclusion of capabilities

A capacity to decode patterns, images, signs or words is essential for drawing conclusions from sets of information. While we primarily use sight, the human sense of touch is an informative and useful perceptual system (Klatzky and Lederman 2002), which enables us to modify and manipulate the world around us (Sukhatme et al. 2001). An embodied knowledge is fundamentally derived from our capacity to be immersed through experiences with the body. With current rapid advancements in digitalisation and digital realities, we are experiencing a cognitive capitalism that is primarily driven through the visual. As can be argued, brain-hand-data relationships have become dissociated, with vision as a sensory substitution for tactile information. Tactile sensation, perception and cognition are linked through information being processed in a bidirectional exchange in a bottom-up (from sensation to cognition) and top-down manner (from central cognition to tactile sensation) (Spence and Gallace 2007). Moreover, reality is a subjective interpretation of facts, and reliant on a cognitive bandwidth across different perceptions and experiences. Beyond the universe of the visual, an understanding towards tactility can offer a potential to yield further dimensions of space, spatiality and environments as social and material constructs. In this context, tactile learning provides a useful method for processing the acquisition of information, and sighted people can benefit from a different understanding through touch that exists within the blind and partially sighted population.

2.1 Cognition and information processing

Tactile information processing can be learned through intensive training such as moving index fingers and adjacent and contralateral fingers over a surface that contains information on a context or environment

(Ravisankar and Brundha 2016). Research shows that people learn to perceive (and replace) a large amount of information gathering by means of their sense of touch (Nicholas 2010), based on the fact that tactile stimuli function similar to vision (Heller 1989). The plasticity of the brain allows us to adapt to a loss of sight by enhancing the response of receptors and nerve endings (Wong, Gnanakumaran, and Goldreich 2011). Effectively, tactile and visual stimuli then lead to similar patterns of neural activation and knowledge as a consequence of the nature of mental representation that enable us to interact with the world, such as spatially based images (Ricciardi et al. 2006). Visual loss can thus be compensated for over a period of time, and so tactile learning and information processing provides an important means to connect and interact.

For cognitive development among blind and partially sighted people, raised-line images and text play a leading role (Kirby and D'Angiulli 2011) across categories of spatial comprehension, short-term memory, object identification, raised-shape identification, sequential scanning, and texture and material discrimination (Withagen et al. 2010). Braille text and graphics enable literacy in blind children if presented early, where tactile literacy is crucial for reading, writing or calculating – decoding signs and words as an ability to draw conclusions from text and graphics and to connect to one's own experiences (Rönnbäck and Viktorin 2015).

2.2 Tactile image representations

Tactile images are commonly based on transfers of visual sources, such as relief images from standard storybooks or school texts or maps. Whereas raised images can generally be understood by the blind (Kennedy 1993), translations from two-dimensional representations to a relief or raised image need to be considered carefully as they are 'scanned' simultaneously with the fingertips of both hands. Tactile displays can be fabricated through thermoforming a plastic sheet over a raised image relief, or printed directly on swell paper. Representations should be accompanied by a descriptive text (referring to image content) or picture guidance (referring to how to read different parts) (Eriksson 2003). Importantly, customisation and fabrication is time, labour and cost intensive.

Beyond direct replicas of visual depictions (Rosenblum and Herzberg 2015), images must be interpreted to fit criteria: First, whereas a sighted person perceives both pictures and details as an overview, a blind person feels elements piece by piece and section by section and so assembles an understanding of the whole (Christensen Sköld 2007). Second, transferring pictures to relief for tactile scanning requires an understanding of simplified representation (Eriksson 1999). Objects and shapes that form the pictorial content must be distinguished by shape, size, patterns and material characteristics (Baumgartner, Wiebel, and Gegenfurtner 2015). Whereas the eye can access innumerable patterns within one picture, reading textures with a finger is particularly hard to interpret when content overlaps. Third, colour information in general and particularly shades of colour cannot be perceived, so colour is of secondary importance. Last, tactile images are size-sensitive, and scale-dependent as readability depends on the dimensions of fingertips and hand size (Eriksson 1999). The maximum size of any tangible graphic must be designed according to the space that the two hands can easily reach together (with approximate A3 dimensions for a comfortable hand position). These criteria are significant for pictorial information and patterns designed as shared and differentiated stimulants for sighted and blind audiences.

2.3 Approach: universal design principles

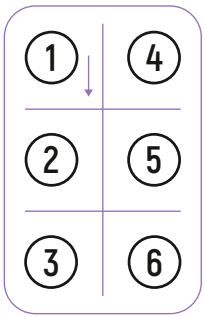
To further inform tactility, Universal Design (UD) strategies support the integration of a wide user spectrum of people with diverse abilities (Preiser and Ostroff 2001). UD addresses specific mobility, dexterity, sensory, communication impairments, or learning disabilities of people who should be supported by thoughtfully considered environments. In a seven-step approach, UD aims to 1) provide the equitable use and accommodate a wide range of preferences and abilities; 2) be flexible in use; 3) be simple and intuitive to use with ease of understanding; 4) provide added dimensions of communicating information regardless of the ambient conditions or the users' sensory abilities; 5) allow for error and not pose hazards; 6) require a minimum of effort; and 7) be appropriate in size and space.

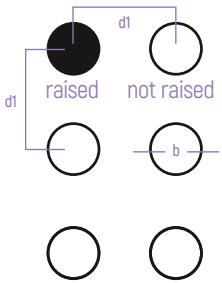
BRAILLE CELL:
the physical area which is occupied by a braille character

BRAILLE CHARACTER:
any one of the 64 distinct patterns of six dots, including the space, which can be expressed in braille. The cell for the letter A.

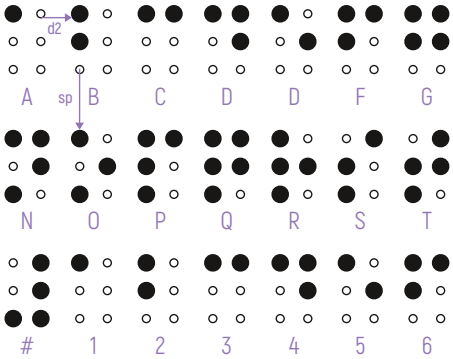
BRAILLE ALPHABET:
including letters, symbols, numbers and national characters depending on country.

d2. distance between dots in adjacent cells
sp. line spacing between characters in text





b. dot base diameter
d1. distance between dots in same cell



Braille is commonly used as a tactile writing system by blind or partially sighted people. The system is based on a 2 × 3 vertical grid (braille cell) with six dots positioned to formulate alphabet, numbers, punctuation and special symbols (braille characters), following the Marburg convention of relational distances between braille dot size, spacing within cell, between words, and distancing lines.

By adopting UD as a driver for computation and advanced manufacturing, generative design processes and customised fabrication can be geared towards a socially oriented computation.

3. Research

Through digital customisation and non-standard production, computation can be deployed towards social and creative suggestive systems. Consequently, the research investigated an approach that combined tactility and vision for scripting and robotic fabrication of a) a texture archive with braille text, images, shapes and textures, which were consecutively embedded in b) hyper-artefacts in the form of multi-functional furniture objects that distribute information for sighted and tactile audiences, as discussed in the following.

3.1 Braille as text-based information

Braille text commonly uses three-dimensional raised dots on formable media (embossed on paper, cardboard, thin metal or plastic). The braille system is based on a cell of six points in a 2 × 3 vertical grid (two parallel vertical lines of three dots each), which organises 64 different braille characters for the alphabet, including numbers, punctuation and special symbols relative to language (PharmaBraille n.d.). In braille Grade 1, unified standards regulate dot sizes, distances between characters, signs and words, and lines between text (UK Association for Accessible Formats 2017). Each possible arrangement of dots within a cell represents one letter, number, punctuation sign, or special braille composition sign as a one-to-one conversion. In data translation, the research considers braille dots as pixels by which surfaces can

be coded to inform material shape-ability and thus provide a tactile language.

3.2 Scripts for robotic manufacturing

An initial series of scripts was developed in Grasshopper (GH, a visual scripting software) to enable the computational workflow for robotic protocols. This included control over dot grids (as braille translator); pixel grids and bitmap (for image conversion); and line tracing (for boundaries and shapes implemented as a robot tooling path):

- In Script 1 (braille), a common online braille Grade 1 translator and font (Unified English braille Code 1)[1] is deployed. This script integrates braille text as a translation into points that reference braille stand ards for cell and character, and a per line approach to situate a number of words within a surface. Through robotic fabrication, cavities are subtracted from a timber surface so metal spheres can be inserted to provide raised text segments.

- Script 2 (Pixel/Bitmap) transfers pictorial data as a pixel sequence, whereby the braille six-point grid is multiplied to form a grid surface. The script remaps values into a point grid for robotic milling, expressing depth with gradations of shades. Pixels here are considered the smallest controllable element by which an image can be represented using RGB image values as resolution for depth mapping.

- Script 3 uses surface manipulation through robotic milling techniques, where the resulting surface is a function of line and tool size, resulting in shapes and forms that represent topographical data, maps, or mathematical formulae. The incremental robot milling into timber surfaces provides variability for line origin data, and makes it possible to manipulate the subtractive milling by varying path lines, depth, angle, repetitions and speed.

1 Standard Braille online tools are available: https://www.brailletranslator.org/, or https://lingojam.com/BrailleTranslator, or http://robobraille.org/. Accessed 1 June 2019.

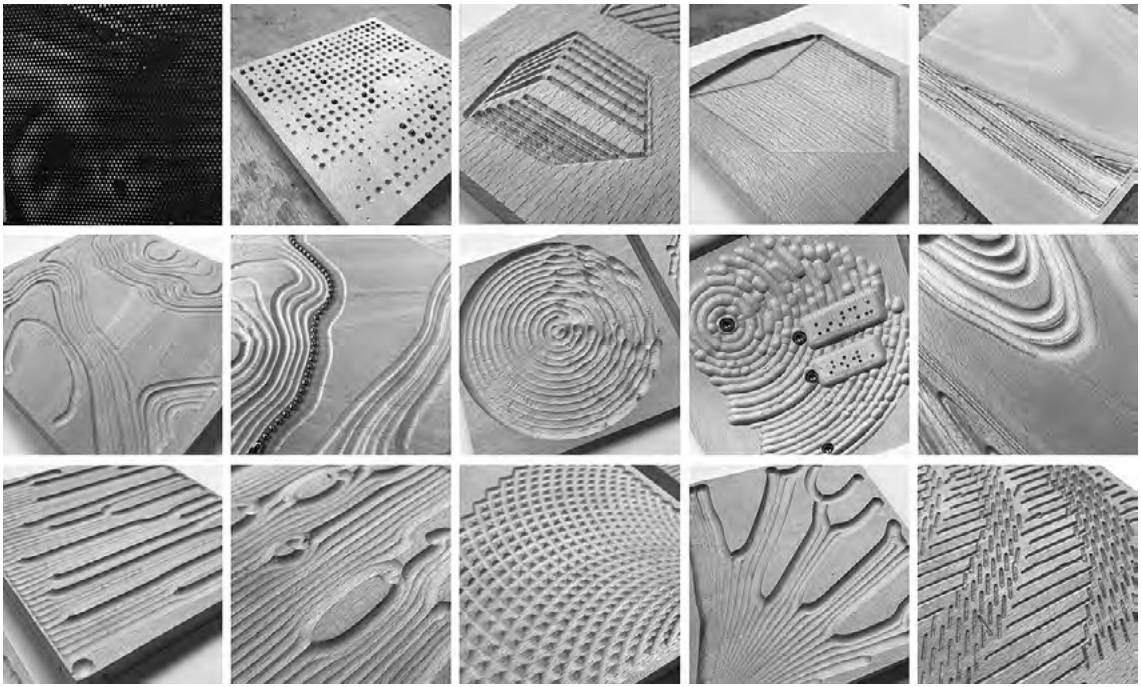
3.3 Tactile archive

The scripted algorithms provide sets of weighted instructions, so surfaces in the tactile archive can be considered charged fields that test a spectrum of approaches within design iterations. These include the direct photographic transfer of recognisable images to a point grid (visual/ tactile), parametric programming of fluid patterns (investigating directionality and spacing of patterns), picture transfers as line tracing coupled with text field inserts and braille text, discrete patterning with incremental spacing for order, mapping of topographical lines for manual readability, or transfers of pictorial display for platonic solids (cube as perspective representation). Thirty-six plates (beech, 10×150×150mm) were fabricated using a standard six-axis industrial ABB IRB 120 robotic arm (robot programming and toolpath simulation in Axis), using standard tools (Dremel/router, tool dimension 1.5, 6, 8, 10mm). By controlling the robotic toolpath, fabrication angle and tool dimensions adopted for manufacturing, discrete elements were produced that render computation directly available for human touch. A preliminary feedback on 'readability' and usefulness for blind or low vision audiences as an interpretive tool of these samples was provided by IBOS.

3.4 Hyper-artefact series (Stool)

Adopting a combination of patterns and braille strategies, the research further investigated 1:1 demonstrators as a generic stool with variable joints (350mm diameter, 40×450mm, beech). Top plates were 3/5-axis CNC milled to include joint cavities, and robotically milled to integrate pattern textures with variable dimensions and depth, commonly leaving a respective subtractive depth for patterns of d<10mm. The design framework required inclusion of braille text and patterns integrated in the top surface, surface edges, underside, or within leg elements. Each hyper-artefact explored narratives for tactility and vision, through a combination of pattern and text:

- The 'Alphabet Chair' introduces the braille alphabet using cells and corresponding engraved Latin letters (a, b, c, d …). To this extent, the circular surface of the seat is adopted as a primary figure, and further used for subdivisions similar to a chronometer.



Excerpt of archive series with scripts regulating surface criteria through organisation, density, order, and the recognisability of patterns. Design variability from deep contrast pixelation to adaptive braille inserts, and perspective interpretation to topography and dynamic fluids.

The top surface is divided geometrically into elements related to the circle as a primary figure, with three parts at 120-degree angles, and divided in 30 segments that present an introduction to the braille Alphabet with 30 parts relative to the Danish alphabet (29 letters plus 1 break). In addition, numerical data are employed for a display that introduces numbers and communicates calendar units.

- The 'Topographical Map' explored maps for understanding space and geographical formations on a larger scale. Characteristics of a mountain range and riverbed introduce settlements and changes to a city over time, with a topography as a three-dimensional map supported by material changes (timber/metal).

- 'Woodgrain' translates material characteristics such as different types of wood grain as a distinct marker of trees. Every timber element reads as a recognisable grain structure of naturally occurring patterns such as rays, cathedrals, vessels, or figures. Through tracing the depth of the natural contours accentuated in robotic milling, tactile tracking of the direction of the wood fibre is enabled.

- 'Flowers and Fluids' explores two variations of botanical precedents as generative patterns. These compare visual perception (simultaneous) and tactile perception (sequential) for assimilating the same information. Both prototypes investigate pattern formations and the organisation and repetition of elements. Braille text establishes signifiers for interpretation by offering juxtapositions or additions, such as 'order-dissolve', 'harmony-endless', 'repetition-asymmetry'.

- Navigating spaces and urban environments can be informed through maps with information on landmarks, points of interest and a general overview of a city, and so play a significant role for understanding a city. 'At Your Fingertips' creates a map of relations between key points in a city centre where markers

and labels convey relations, and a coastline as a means of orientation. Braille text embedded in the surface indicates the main programmes of public spaces such as church, music school, museum or community services.

4. Discussion

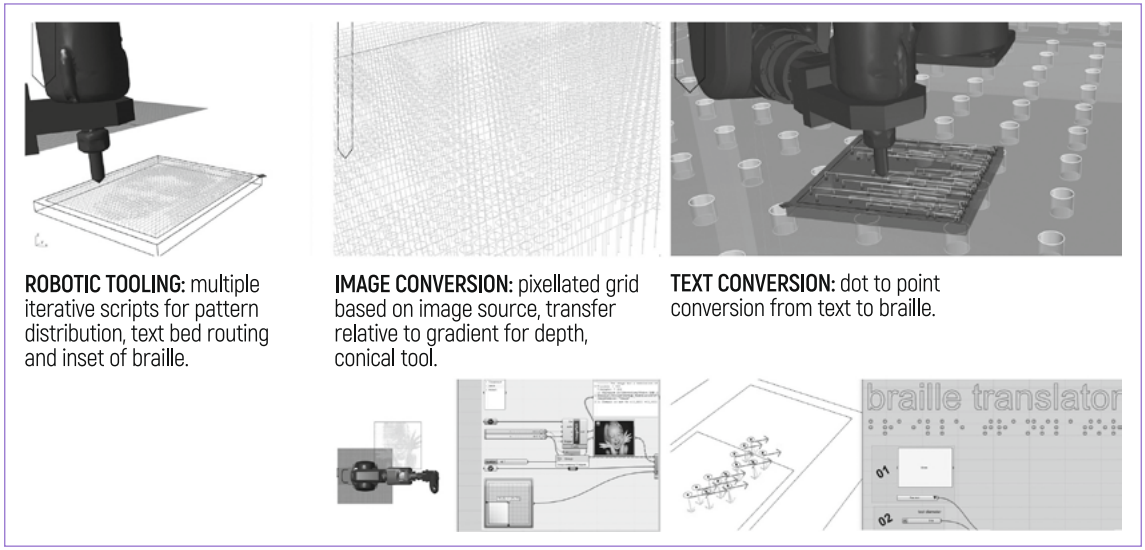
Through consecutive testing of the initial research, tactile archive and hyper-artefacts in discussion and feedback with different audiences, further aspects could be derived:

4.1 Understanding blindness better

The direct feedback from blind and partially sighted participants (IBOS) on the braille text and pictorial/pattern conversion allowed us to evaluate the adopted approach to tactility. In particular, we learned that the information presented has to be fundamentally considered from a bottom up perspective for readability of the tactile information. In decoding patterns by touch, the appropriateness of the scale relative to the human body together with a clear distinction of data provides a significant aspect. This stands in contrast to computational design approaches where generative scripts are commonly adopted to explore design complexity and ambiguity. Here, being able to read information in sequence, and to be able to derive data hierarchies was important, and so designs of textures and text have to be considered by designers in a highly different manner to those for sighted audiences.

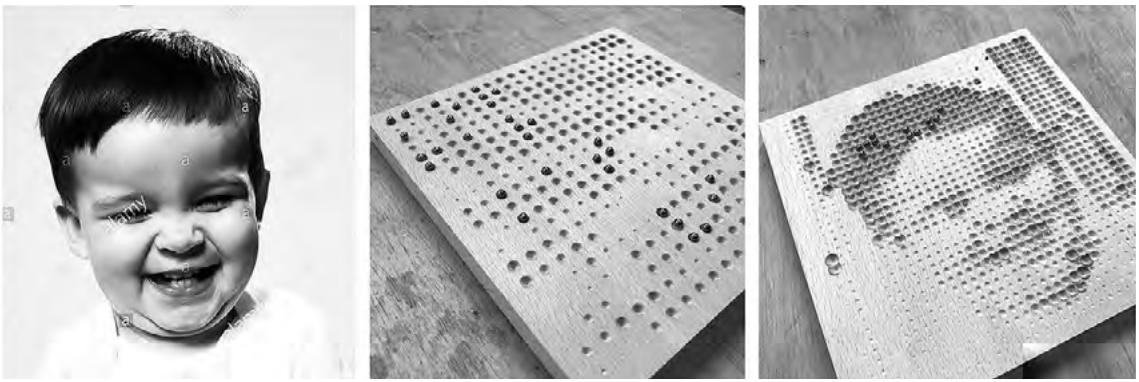
4.2 Robotic braille

In the studies, braille text conversion was successfully implemented across a range of applications from planar surface integration to three-dimensional objects. Braille GH scripting and robotic tooling could be successfully implemented for the rapid execution of text. Precise tracking of dot positions had to be conducted, as the braille code becomes illegible for designers and fabricators while in process. Initial studies showed that braille text needs to conform to near-equal dimensioning to standards in order to be legible. It was further stated that signifiers were needed in order to recognise overall text segment position, orientation and preferably reading direction together with an index for sufficient recognition, particularly where embedded in multi-dimensional data surfaces such as the chair.



Robot tooling for pictorial-to-tactile information and braille. Sets of GH scripts were developed to transfer data to robotic toolpath (Axis). 01 shows robot and target area with image content, 02 illustrates pixelated zones, 03 shows conversion from written text in translator to singular braille dots for milling.

01 02 03



Combinations of pictorial information and braille. Step 1: image source with RGB values used to instruct depth and angle for robot milling. Step 2: increased point grid with braille inserts (text inserts: 'mor', 'far', 'kat'). Step 3: graphical material is analysed for potential overlaps with the braille, with locational information of graphical material overlaid with braille inserts.

4.3 Tactile diversity

A range of three-dimensional surfaces was produced, whereby the robotic process of tooling patterns proved a fast, economic and affordable method for the singular, customised and iterative fabrication of surfaces that would have been difficult to manufacture through standard carpentry methods. This tactile archive provided sufficient samples to enable a structured survey with blind participants (IBOS). In a guided study, pattern samples and chairs were tested in a structured interview. Initial results for evaluating surface performance through touch delivered key signifiers for conceptualising three-dimensional aspects of tactile patterns. This included a) preference for hierarchies to derive an overall understanding of the image represented; b) appreciation of pattern diversity and variation within differentiated fields; c) preference for material changes as an expression of data; d) an indication that understanding and readability could be increased by accompanying signifiers and explanations. Most importantly, and while participants communicated cognitive delight, the subjective interpretation of patterns and individual preference varied widely between the different participants.

4.4 Decoding hyper-artefacts

Tested across blind user studies and as a public exhibition format, the chair acted as a tool for communication and discourse. In adopting Universal Design principles, these multifunctional objects proved successful in integrating both visual and tactile stimuli. Moreover, the versatility these common objects provide – based on their indiscriminative and explicit use – enables responses to different bodies and functions. They further act as multiples for a conversational round, and so enabled a 'situationing' of space and performance. Surfaces mediated three dimensions of information: 1) visual information decoded by sight, 2) tactile information decoded by sight and touch, and 3) tactile text for braille competent readers. As evidenced, interactions between blind and sighted audiences were increased in decoding images and respectively braille text, thus encouraging exchanges and increasing awareness and empathy between both sighted and tactile cultures. Significantly, this indicated potential for positive changes in attitudes and behaviour towards inclusion.

While these studies gauged considerable interest, further studies are required, particularly with users, to asses further design potentials, readability of project content, reading directions for braille inserts, performance of objects subjected to repeated use over extended periods of time, and capability for an expanded thematic range.

Overview of chair variants and surface details. From top left to right: spelling game; woodgrain; Apollo II landing; perspective; spatial maps; alphabet intro, topography, directions; flowers and fluids.

5. Conclusion and future work

This paper has introduced research into design for the tactility of informational surfaces for audiences with diverse tactile and visual capabilities. Through the development of process and methods, sample archives and (object) prototypes, the research increased knowledge on tactile information processing and interpretive narrative. The research found that tactile surfaces with pictorial and textual content can support more inclusive environments by offering a range of sensory triggers for people with different sensory capacities. These initial studies could be extended towards developing design guidelines for tactile information for educational purposes, using computational design and customised fabrication techniques for tactile information processing. By adopting current digital methods and practices, tactile information processing for blind or low vision audiences could be further improved. Moreover, by integrating these aspects using Universal Design strategies for public spaces, means can be derived for establishing community, participation and engagement of activities for a combination of blind, partially sighted and sighted people.

In extension of the initial research, future trajectories could include a) studies of tactile patterns in relationships between cognition and memory, b) development of tactile maps and objects to improve mobility and autonomy, c) support of educational and pedagogical material for increasing tactile literacy,

and d) development of hypermedia environments for museums and public institutions. Beyond a universe of the visual, this supports the potential of computational design and advanced robotic fabrication in support of touch, for tactile cognition and learning by the blind, partially sighted, and sighted, in support of different paradigms of space and spatiality.

Acknowledgements

This is an ongoing research collaboration between the RoboticsLab, Aarhus School of Architecture, Denmark, and IBOS – The National Institute for Blind and Partially Sighted, Copenhagen, Denmark. Produced with the AARCH workshop team: Jan Horlock Jensen, Jesper Kobbero, Max Buthke, Mathias Orum Norgard and the HC2019 students: Mette Holm, Cecilie Elmholdt Smidt, Rikke Friis Sørensen, Klaus Schytt Simonsen, Max Arpe-Sørensen, Adam Marcel Nielsen, Brita Melander, Bastian McLean Gosvig, Christian Bjerrum Poulsen, Marie Hjulmand Emborg, Lena Mortensen, Anna Vidje Lundahl, Jo Suul, Said Boujakhrout, Andreas Ørbæk Damm, Marc Frederik Roi Bak, and Jakob Hammer Thuesen in praktique.

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Dr Dagmar Reinhardt

is an architect, researcher and educator, and a principal of reinhardt_jung (www.reinhardtjung.de), a research-based architecture practice that deals with affordable and multi-generational residential works. reinhardt_jung's work has been widely published (*Frame, Mark, Detail*), and awarded numerous prestigious prizes.

Reinhardt is an Associate Professor at the Aarhus School of Architecture, Denmark, where she leads the robotics lab, and an Associate Professor at the School of Architecture, Design and Planning, The University of Sydney. Reinhardt's research explores the way in which architectural performance can be informed by simulation and feedback with acoustic, structural or constructive criteria, and thus provide higher quality and more sensitive, human-centric spaces. Reinhardt investigates opportunities for leveraging robotic fabrication methods to adapt geometry, materiality and construction methods within design technology, so novel solutions become available for the difficult relationship between human labour and construction automation in the building trades.

Reinhardt was Co-Chair of Rob|Arch2016 Robots in Architecture, Art and Design (www.robarch2016.org) and has led substantial industry and government funded projects on new robotic applications for workspace scenarios, and for safer and healthier construction work environments. Her upcoming book on 'Design Robotics' will combine generative design, robotic fabrication, timed materiality and spatial programming, and the bridge between architecture, social, collaborative and creative robotics.

TRANSINDIVIDUAL URBANISM

NOVEL TERRITORIES OF DIGITAL PARTICIPATORY PRACTICE

Annarita Papeschi
The Bartlett School of Architecture,
PhD Candidate & Theory Tutor
Flow Architecture, Director

Abstract

Like an omen, the advent of ubiquitous technologies has carried the general expectation of the emergence of new forms of collective authorship. Drawing on the cybernetic theory of communication and on the work of French philosopher Gilbert Simondon, the paper builds an ecological and materialist foundation to ideas of digital participation by presenting a discussion of Simondon's *L'individuation Psychique et Collective* (1958). Here, the philosopher describes the individuation of the collective subject as an ontogenetic and metastatic process of psychological and affective events producing the Transindividual, thus offering a biological interpretation of the social process of becoming and a reconceptualisation of ideas of knowledge and the distribution of information.

By opening digital participatory scholarship to ecological and post-humanist theory, the paper intends to offer a better understanding of the complex nature of collective feedback, creating the potential for the affirmation of novel mediated urban narratives and aesthetics. These ideas are further explored through a design-research practice that uses biometric sensing, live data visualisation and generative design to investigate the aesthetic, technological and cultural dimension of transindividuality as a model for collective authorship.

The paper presents two projects, The HeartBit Walks and Affectual Infrastructures. These were designed as participatory events for larger event series in London, respectively the London Festival of Architecture 2018 and the E17 Art Trail 2019.

Developed as a psychogeographic mapping event in Hackney Wick, The HeartBit Walks builds on previous methods developed by artist Christian Nold, investigating the use of biometric sensing (Galvanic Skin Response) and live data-visualisations for urban analysis. GSR information was gathered during short group walks and visualised during in-situ group discussions as situated dynamic animations, exploring the modes of the reconfiguration of group knowledge through the experiential act of walking. The results were collected in a rich visual index that, by rendering the diverse perspectives with granular definition, offers a multi-scalar photography of the pedestrian mobility issues in the area.

Drawing on the methods first explored in The HeartBit Walks, the Affectual Infrastructures project involved six environmental activists in the collection of environmental sound and GSR data at key locations in East London. The project attempts the detection of common sonic, spatial and emotional connections through the observation of data

patterns at group level, exploring the metastatic formation of novel collective environmental awareness and the production of spatial configurations through multi-objective evaluation methods. The results inform a multimedia installation that, working as an adaptive network, releases at intervals the intertwined local sonic recordings, thus materialising for the public the intertwined situated experiences of the activists across space, time and individual identities.

Within an ecological angle that places humans and their living and non-living co-species as the network of actors that collaboratively addresses the production of space, the Transindividual Urbanism project proposes biometric sensing as a tool for the systematic deconstruction of human agency and the reimagination of platforms for group knowledge creation and collaborative decision-making. By constructing open archives of sensual collective knowledge and exploring generative mechanisms of real-time reflexive awareness, the project radically challenges previous conceived ideas of distributed authorship defining new trajectories of operation with the potential for radically reshaping the processes through which culture and places connect locally.

Keywords: biometric sensing, citizen science, collective authorship, participatory design, Simondon

1. Introduction

A few years ago, I came across a little fascinating publication titled "Suspicious Images, Latent Interfaces". The pamphlet, published in 2009, consisted of a light-hearted conversation between Benjamin Bratton and Natalie Jermijenko discussing data visualisation, where the two argued in favour of what they perceived as a yet-to-be realised potential for data-viz to act as political dashboards (Bratton and Jermijenko 2009). A decade later, the emergence of ubiquitous computing on a global scale has certainly contributed to the wide spread of this expectation and reinforced the anticipation of distributed intelligent mechanisms of decision-making.

Within a parallel discussion on digital customisation and authorship, Carpo (2017) indicates how a still rising expectation for participatory features in architectural design may be linked to the emergence of computational methods since the late 1990s and early 2000s. I would argue with Carpo that the promise of a digital participatory turn is today still largely unmet. This is true, despite the number of projects that have more recently addressed the mechanisms of the digitalisation of participatory urban practices on the one hand, or the participatory potential of digital fabrication on the other. These two distinct trends, which include the exploration of methods for collective knowledge aggregation, as well as the formulation of technological platforms for open purposive action on an architectural scale, describe together the focus of what I will address as current digital participatory scholarship.

Wikipedia House represents a good example of the limits and idiosyncrasies of current architectural-scale online open-fabrication. The project, described by Ratti (2015) "as an online, open source platform of user generated housing designs, that anyone can download and print with plywood on a CNC mill and snap together like IKEA furniture", sits online today as a barren shelf offering a single house type, the type originally designed by its founders as a prototype for the project. Since its launch the library has been sparsely used and nobody seems to have responded to the invitation for contributions to its online open extension (WikiHouse n.d.).

On the opposite side of the spectrum, Nold (2018) offers a fundamental critique of responsive urban planning projects that have attempted the integration of mechanisms of feedback to emotive datasets, and points out how by rendering emotional events as an abstraction, through what is a reductionist operation of quantification of qualitative information, these methods cut de facto the happenings off from their causations, with an approach that ultimately sabotages the significance of the research findings and trades the possibility of discovering meaningful urban narratives for a misconstrued urban-scale real-time responsiveness.

Despite the fact that the two cases just mentioned sit at opposite ends of the digital participatory project spectrum, they share a common base in what seems to be a lack of attention toward the political and cultural dimension, a trait that also translates in the production of a deep disconnection between the agencies and motives of these projects and the related proposed materialities and modes of production.

2. Constructing participatory ecologies

My premise is that acquiring a philosophical perspective towards the topic of participation is paramount in order to radically re-imagine the cultural and technological basis of the collective project. For this purpose, I draw initially on the ecological project of Gregory Bateson, and on the ideas on subjectivity and communication developed in his essay 'Form, Substance and Difference' (Bateson 1972).

Here Bateson describes *information* as something that is brought about by *differences*, as in the case of the territory and the map, where the information that gets onto the map is only given by the discontinuities of the territory, such as peaks or borders (Bateson 1972, 457–458). *Paths of information*, he continues, are not only limited to the body, and, despite there being differences between the paths inside and outside the body, the world of information processing is not limited by the skin (Bateson 1972, 460).

In principle, he continues, if you want to explain anything in human behaviours, you are always dealing with complete circuits of information. "The elementary cybernetic system with its messages in circuit is in fact the simplest *unit of mind*; and the transform of a difference traveling in a circuit is the elementary idea" (Bateson 1972, 465).

Drawing upon this systemic notion of *mind*, Bateson expands it further by discussing the limits of its subjectivity, and argues: "suppose I am a blind man, and I use a stick … Where do *I* start? Is my mental system bounded at the handle of the stick? Is it bounded by my skin? Does it start halfway up the stick? [...] The stick is a pathway along which transforms of difference are being transmitted. The way to delineate the system is to draw the limiting line in a way that you do not cut any of the pathways which leaves things inexplicable" (Bateson 1972, 465).

Ultimately, for the mutual identity to the cybernetic system, he concludes, the *unit of mind* and the non-homogeneous *unit of evolutionary survival*, as developed by the contemporary theory of genetic, coincide. "The identity between the unit of mind and the unit of evolutionary survival is of great relevance", Bateson concludes, as along with this reasoning it is possible to localise an *immanent Mind* in the large biological system, the ecosystem (Bateson 1972, 466).

While this text is central in identifying the key concepts that entail the radical ecological redefinition of epistemology, the discussion around its social and political impact certainly also needs to take in consideration Gilbert Simondon's theory of collective individuation. This is a critical contribution, for its holistic aspiration at connecting psychology to social and

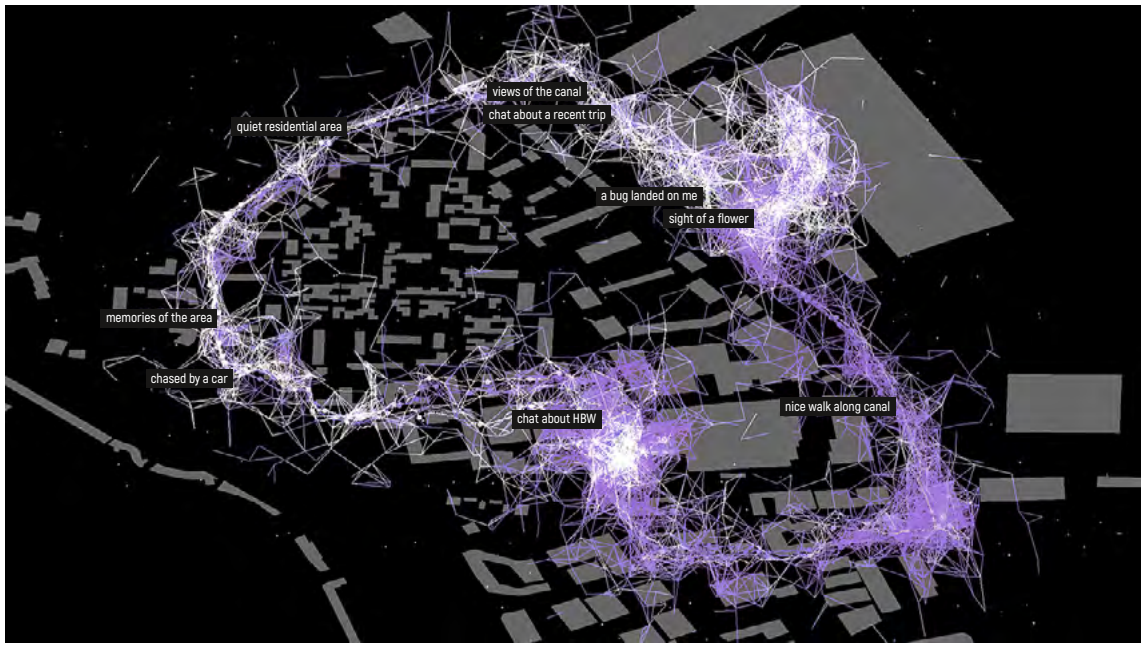
behavioural sciences through an original ecological and materialist perspective, a contribution that has unfortunately only been published in fragments in English.

3. Psychic life and quantum physics: Gilbert Simondon

"*… becoming is not a framework in which being exists; it is one of the dimensions of the being, a mode of resolving an initial incompatibility that was rife with potentials*" (Simondon 1992).

Gilbert Simondon's published work is quite limited, and in essence confined to his doctorate thesis and his complementary dissertation both written in 1958. But while his second dissertation – with the title of *Du Mode d'existence des object techniques* – was published in the immediate aftermath of his doctorate discussion and had immediate impact, his main dissertation had a more complicated destiny, with only the first part – *L'individu et sa génèse physico-biologique* – published in 1964 and the second part – *L'individuation psychique et collective* – only published in 1989 in French and never published in an English translation in its entirety. Only a fraction of the introduction, in fact, appeared in the ambitious *Incorporations*, edited by Jonathan Crary and Sandford Kwinter (1992).

In the book, Simondon discusses the ontology of the collective subject in the form of its ontogenesis. As an alternative to the substantialist and hylomorphic theories of subjectivity creation, Simondon builds an energetic theory of the process of becoming a subject – *individuation* – in an argument that, by borrowing at length from the natural sciences, sees the physical, psychological and social processes of evolution as deeply intertwined. As an introduction to his main argument, Simondon first asserts the result



Summative animated data visualisation.

of *individuation* as the couplet subject-environment, and proceeds to observe that *individuation* is a temporary condition that can only manifest in a system with latent potentials as relative resolution. As a result, the idea of the ontogenesis of the subject acquires in Simondon's cosmos its full meaning only by designating a continuous process of development (Simondon 1958, 28).

Physical individuation, the first of the stages of *individuation*, is described as the case of the resolution of a metastatic system. Here, Simondon offers the example of the genesis of crystals, where the process of *individuation* is not given by a combination of form and matter, but by a resolution from within a metastatic system with rich latent potentials (Simondon 1958, 30). The next stage is the *individuation of the living individual*, in which, Simondon argues, the *individuation* is not abrupt and final, as the living subject keeps the permanent ability for new individuations: "not only he [the living individual] is the result of the individuation, as the crystal or the molecule, but the theatre of the individuation" (Simondon 1958, 32).

Finally, "with an analogue hypothesis to the one of quantum physics" Simondon observes how it's possible to imagine that a regime of metastability may be preserved and conveyed by the individual, and that *participation* may be part of a larger process of *individuation* enabled by the pre-individual reality of the individuals and their potentials (Simondon 1958, 33). *Psychic individuation* and *collective individuation* are the two following steps that describe the internal and the external relations of the individual. The two individuations have a reciprocal effect on each other and allow us to define the category of the *transindividual* as a new type of collective subjectivity that, born from an authentic new operation of individuation, lives its own changes on the basis of its own specific metastaticity (Simondon 1958, 34).

As Simondon further explains, life as individuation is conceived as a discovery, in a conflictual state, of a new axiomatic that incorporates and unifies in the comprehensive system of the individual all the elements of that condition (Simondon 1958, 35). Knowledge therefore needs also to be redefined, as it cannot be built on the basis of abstractions from sensations, but "through a problematic deriving from a primary tropistic unity, a coupling of sensation and tropism, the orientation of the living being in a polarised world" (Simondon 1992, 309). Building an antagonist argument to the theory of the information of Shannon, Fisher, Hartley and Wiener (Simondon 1958, 61), Simondon therefore explains that "information is never found, but always results out of the tension between two different realities; [and that] meaning will emerge only once a process of individuation will clarify the dimension through which these two realities can become a system" (Simondon 1958, 37).

By redefining the idea of collective subjectivity as a process of change through metastatic phases moved by psychological and affective events, and with the resulting re-conceptualisation of ideas of knowledge and information, Simondon not only offers the basis for a reconsideration of the process of becoming collective and building collective knowledge, but with his transversal materialistic and ecologic approach he indicates the perspective through which a novel post-human and distributed form of authorship can be explored.

4. Exploring metastatic platforms

Transindividual Urbanism formulates a design-research practice that uses historical research, participatory urban analysis and design speculations to explore the aesthetic, technological and cultural dimension of transindividuality as a generative model for collective authorship. With an ecological angle that places humans and their living and non-living co-species as a network of actors that collaboratively addresses the production of space, biometric sensing is used as a tool for the systematic deconstruction of human agency and the reimagination of platforms for actionable group knowledge creation.

4.1 The HeartBit Walks

The HeartBit Walks was developed as a psychogeographic mapping project for the London Festival of Architecture 2018. The project explored a wide section of diverse urban fabric in East London, stretching across the edges of the newly redeveloped Olympic Park and Hackney Wick, with a particular focus on the

The walks in Hackney Wick.

complex network of cycling and pedestrian pathways that offer transversal connectivity across the River Lee and the A12.

An initial workshop took place at the Bartlett School of Architecture, Master of Urban Design, to develop an Arduino portable apparatus that, drawing on methods developed by artist Christian Nold, was designed to collect combined Galvanic Skin Response (GRS) – an indicator of the emotive status also used in lie-detecting tests – and General Positioning Information (GPS). The project continued as a two-day public event, involving 25 participants invited to wear the apparatus during explorative group walks in the area. On return to the meeting point, the detailed emotional insights were visualised during in-situ group discussions that focused on differences between individual and summative experiences visualised as situated three-dimensional models and dynamic animations.

The walks in Hackney Wick.

The various accidents that, as perceived by each participant, had been annotated during the group discussions, were further classified through an identification of the primary and secondary sense. For example, an encounter with noisy school children on a bridge was identified as sound-sight, a mother stopping to breastfeed her daughter on the sidewalk was labelled as touch-smell. As a result, a series of dendrograms and sunburst diagrams were produced to illustrate the relations between the specific sense and the recollections of the events. A particular focus was placed on the analysis of six group walks, with the production of an overall map that visualises the different journeys and the intensities of the summative data for each group, together with a set of additional group visualisations overlaying the GSR data collected from the different participants and the position and the typology of the events.

Overall, these visualisations compose a rich visual index of the event that by rendering the diverse perspectives with granular definition offers a multi-scalar photography of the experience. Not only were the diverse identities of the participants revealed and the details of how their physical and mental abilities affected their experience, but through the vertical sensual categorisation of the events incurred, the different experiences are compared and interwoven in a collective visual diary rich with indications and urban insights.

4.2 Affectual Infrastructures

Drawing on the body of knowledge developed for *The HeartBit Walks, Affectual Infrastructures* was developed for the E17 Art Trail 2019 in London. The project continued to explore the use of GSR information investigating emotional group patterns in urban spaces while initiating a parallel line of research exploring the use of generative algorithms for the production of a collaboratively informed artefact.

Through a call on social media, six environmental activists were recruited. The participants – a mix of academics, designers, visual artists and a psychotherapist – were met at various locations in East London to record a three-minute speech together with the concurrent environmental sound and GSR signals. Data patterns were observed at group level with the intent to detect common sonic, spatial and emotional connections between the various participants at different points in time. A set of the overlaid GSR signals highlighted the linkages at peak emotional moments; the signals were further analysed with consideration of their urban location and overall spatial arrangement making use of a multi-objective genetic algorithm that searched for three concurrent goals: time proximity, emotional proximity and peaks of tranquillity within the group.

The results informed a spatial installation that materialised for the public the layered situated experiences of the participants. Built with a multitude of hand-formed rattan stems that follow the pattern generated through the multi-objective spatial simulation, the artefact spatialises the emotional group condition offering a physical rendition of the intertwined occurrences and, working as an adaptive network, it releases the six ambient and speech recordings edited with an overlaid structure that responds to the specific pattern of emotional proximity in the group as seen by each participant.

A concluding panel discussion was organised with the participants to consider the findings. This was the second time that the group physically met after a first preliminary encounter, and the first opportunity for them to review each other's outcomes. Acting as an open archive of sensual collective intelligence, the installation and the graphic supporting materials enabled the participants to navigate the different points of view and situated happenings. The experience continued de facto the metastatic process of collective subjectivity and knowledge creation, ultimately highlighting how the determination of an iterative mechanism of multi-objective responsiveness could potentially offer further moments of group awareness and more opportunities for collective knowledge and purpose growth.

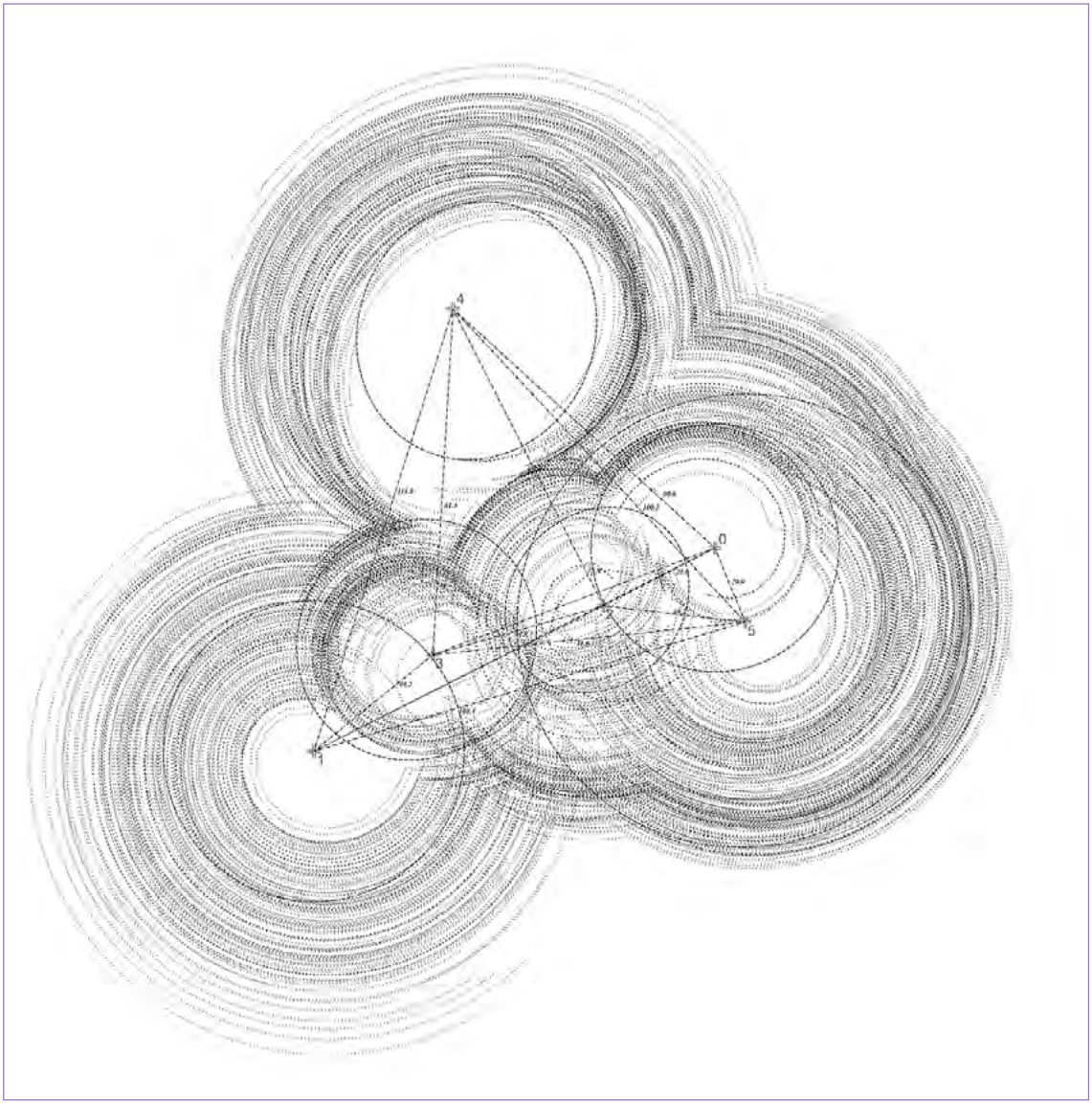
5. Conclusion

The HeartBit Walks and the *Affectual Infrastructures* constitute an initial attempt to explore two critical dimensions of the digital participatory project, dealing on the one hand with the mechanisms for collective knowledge aggregation, and on the other with the

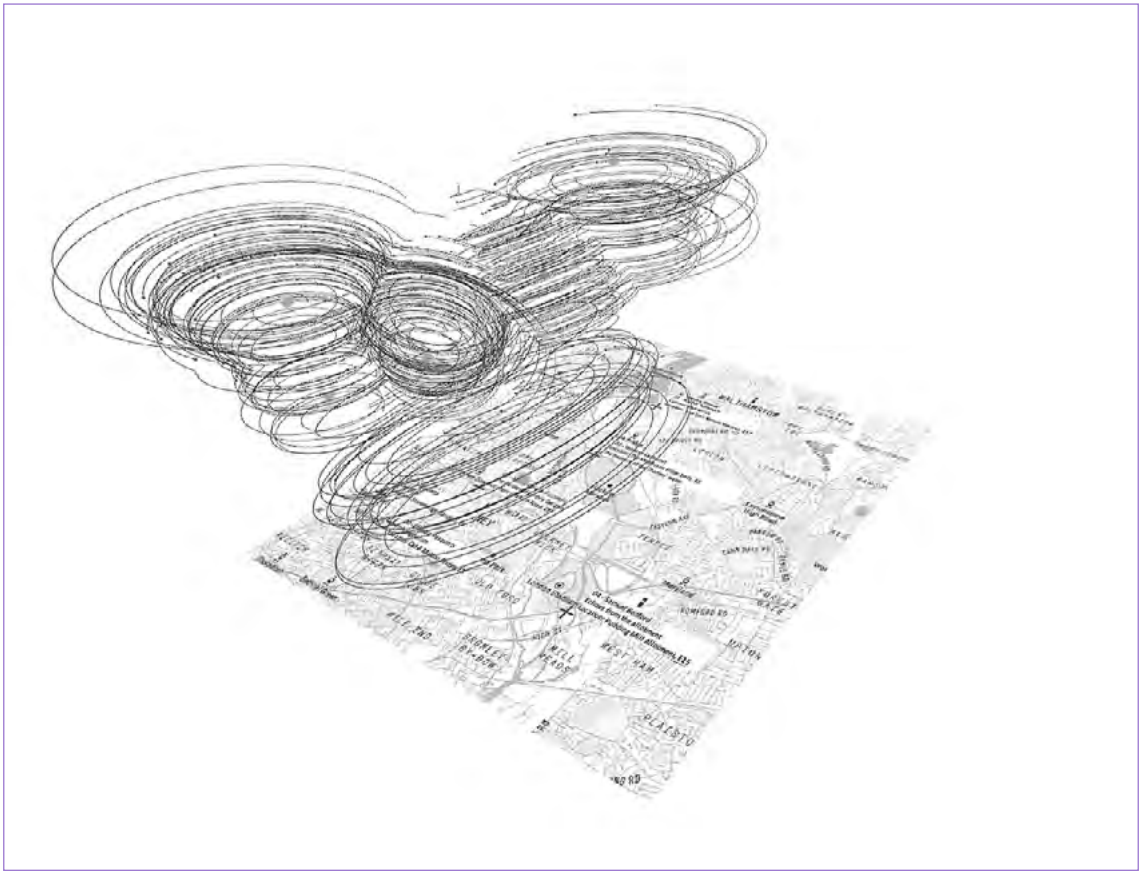
Affectual Infrastructures installation at One Hoe Street, London. Photo: Matthew Booth.

formulation of platforms for open purposive action. In opposition to those cases of responsive design in which the measure of the environmental phenomena is considered in isolation, within a perspective that de facto ascribes the human subject to an isolated and sanitised position, The *Transindividual Urbanism* project proposes biometric sensing as a tool for the systematic deconstruction of the human agency and the reimagination of a collective project that, within an ecological angle, places humans and their living and non-living co-species as the network of actors that collaboratively addresses the production of space.

Within this context, it is through the construction of open archives of a sensual collective knowledge that aims at maintaining traceable ties with their



The digital set up.



The digital set up.

sources and narratives, and through the introduction of mediated mechanisms for real-time awareness seeking to engage metastatic processes of group knowledge and purpose production, that the project offers some precedents for a collective urban practice that, by dwelling on ideas of the open attribution of significance and multi-objective evaluation, offers on a first instance new models of group negotiation and decision-making. But it is by further engagement with Simondon's notion of *tropism*, the complementary half of *sensation* in the coupling of the primary unit from which *knowledge* derives (Simondon 1992, 309), that the project's direct confrontation with space production through generative algorithmic methods takes a central role in the attempt to readdress the endemic disconnection between the agencies, motives, and materialities of the current digital participatory project through informed matter.

The result is an emergent aesthetic that, informed by the close collaboration of matter, technological infrastructures and human behaviours, radically challenges previously conceived ideas of distributed authorship and defines new trajectories of operation for a digital collective practice that have the potential for radically reshaping the processes through which culture and places connect locally.

Project credits

The HeartBit Walks

Psychogeographic event, London Festival of Architecture, 2018
A project by Flow Architecture, Annarita Papeschi and Vincent Nowak
Lead researcher: Annarita Papeschi
Team: Annarita Papeschi, Vincent Nowak, Alican Inal, Cait Brock

Affectual Infrastructures

Multimedia Installation, E17 Art Trail 2019
A project by Flow Architecture, Annarita Papeschi and Vincent Nowak
Lead researcher: Annarita Papeschi
Team: Annarita Papeschi, Vincent Nowak, Jessica Lo Faro, Iva Liberta, Vanessa Panagiotopoulou
With contributions by: Samuel Bedford, Iva Liberta, Vanessa Lastrucci, Claudia Pasquero, Maria Chiara Piccinelli, Rachel Summers.
Supported by a bursary from UCL Culture

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Annarita Papeschi

is a practising architect (ARB, RIBA) and an educator, with a Laurea in Architettura from the Università degli Studi di Firenze (2003) and a MArch in Architecture and Urbanism from the Architectural Association School of Architecture (2007).

She was previously a Lead Architect at Zaha Hadid Architects and co-founded FLOW Architecture in 2013. Working at the intersection of architectural, design and urban research, FLOW's production explores the radical potential of ubiquitous technologies to develop collectively crafted experiences and spaces. They have exhibited and presented their work extensively in the UK and Europe.

Annarita has taught at A&L Greenwich and at the Kent School of Architecture. Currently, she is at Syracuse University London as Adjunct Professor and at The Bartlett School of Architecture as Urban Design MArch Theory Tutor. At The Bartlett, she is also a PhD candidate; drawing on the cybernetic theory of communication, her thesis builds an ecological and materialist foundation to explore ideas of digital participation, and the aesthetic and technological dimension of collective authorship through design-led urban practice.

PROTOTYPING PROTOCOLS: PROTOCOLLING PROTOTYPES

IDENTIFYING AND SYSTEMATISING DESIGN METHODOLOGY FOR CONTEMPORARY MODULAR TIMBER ARCHITECTURE

Sille Pihlak
Estonian Academy of Arts,
Faculty of Architecture[1]

Abstract

For nearly 90 years, the Estonian timber construction industry has been neither sustainable nor automated. However, recent trends indicate the possibility of positioning renewable materials again at the heart of the local large-scale building economy. In recent years, the use of timber construction has increased (Kaufmann et al. 2018), once again becoming part of mass production and re-entering the material library of architectural practitioners. Nonetheless, while architects have been overwhelmed with the abundance of new possibilities and applications offered by contemporary digital tools, the field of construction has remained brutally simple, so the utilisation of wood has often seemed to involve little more than a material translation from concrete.

Redefining the production chain of architecture, from design to fabrication and based on computational fabrication and modularity, may be key to developing a more flexible and adaptable architecture. Given the collaborative workflow that often occurs between architects, engineers and fabricators, modular prototyping can have design implications in both tectonics and spatial organisation. The dynamic relationships between the digital, the material, design protocols and experimental prototypes, thus have the potential to become key elements of the design and fabrication process, and my work explores this potential.

This thesis looks at adaptive design and fabrication methods for working with materials whose properties are not uniform — to capture the potential of live geometry and living materials. By reviewing and analysing the changing relationship between the protocol and the prototype it becomes possible to reveal potential bases for new and more efficient design and construction processes. In particular, this research focuses on workflow based on discrete syntax, and proposes a methodology for enabling all contributors to the composition of the building process — architects, engineers and fabricators — to work in a non-linear, looping manner, around a common platform. The particularities of using natural living materials, with their varying properties, can thus be taken into account throughout the entire

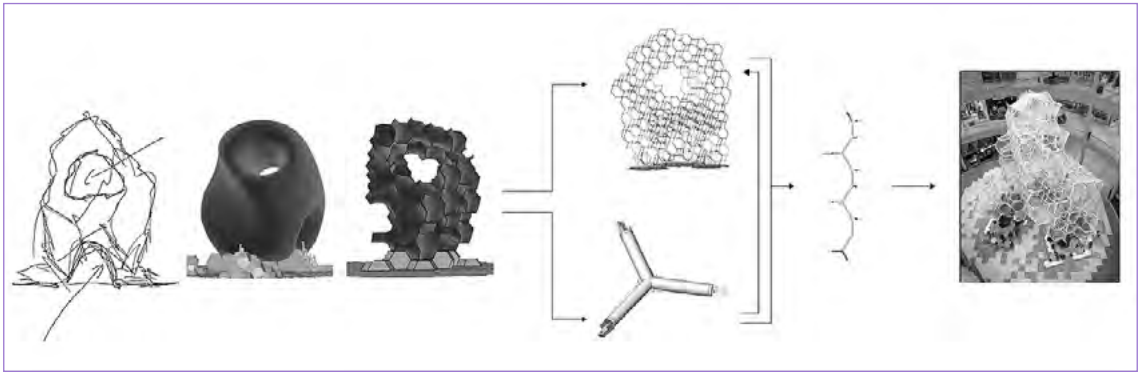
1 Correspondence: Estonian Academy of Arts Faculty of Architecture, PART – Practice for Architecture, Research and Theory, sille.pihlak@artun.ee, +3725150065.

fabrication process. In short, such a methodology dismantles the normal workflow by redefining the relationship between design protocols and fabricated prototypes.

Collaborative work calls for defined design protocols and continuous prototyping. Investigation is required into the means, tools and regulations for large-scale construction, leading to the development of automated protocols from the early stages of the design process to the final building. Obtaining data from the prototyping of modular systems, joinery, combinatory material tests and defining more intelligent components, are already a part of the design process and architectural intention.

Analysis of the processes of my practice is conducted through case studies which, while demonstrating its limitations, embodying the advantages of natural materials and demonstrate the necessity for modularity and repetition in large-scale construction.

Keywords: automation, industrial collaboration, sustainable construction, modularity, Estonian architecture



Installation Urban Jungle. Architecture design diagram, 2019.

1. Introduction

This research project is positioned in the context of an emerging group of architects engaging with sustainable construction materials, modular systems and algorithmic techniques. Its original to knowledge lies in its analysis of design processes in terms of protocols and prototypes, and in describing how the architectural design intention is embedded in a looping workflow. Throughout these processes, the architectural grammar, relationships and procedures are all influenced by subjective values and even more strongly by the local construction scene. By working collaboratively and with a common aesthetic sustainable construction is possible at an urban scale.

1.1 Methodology

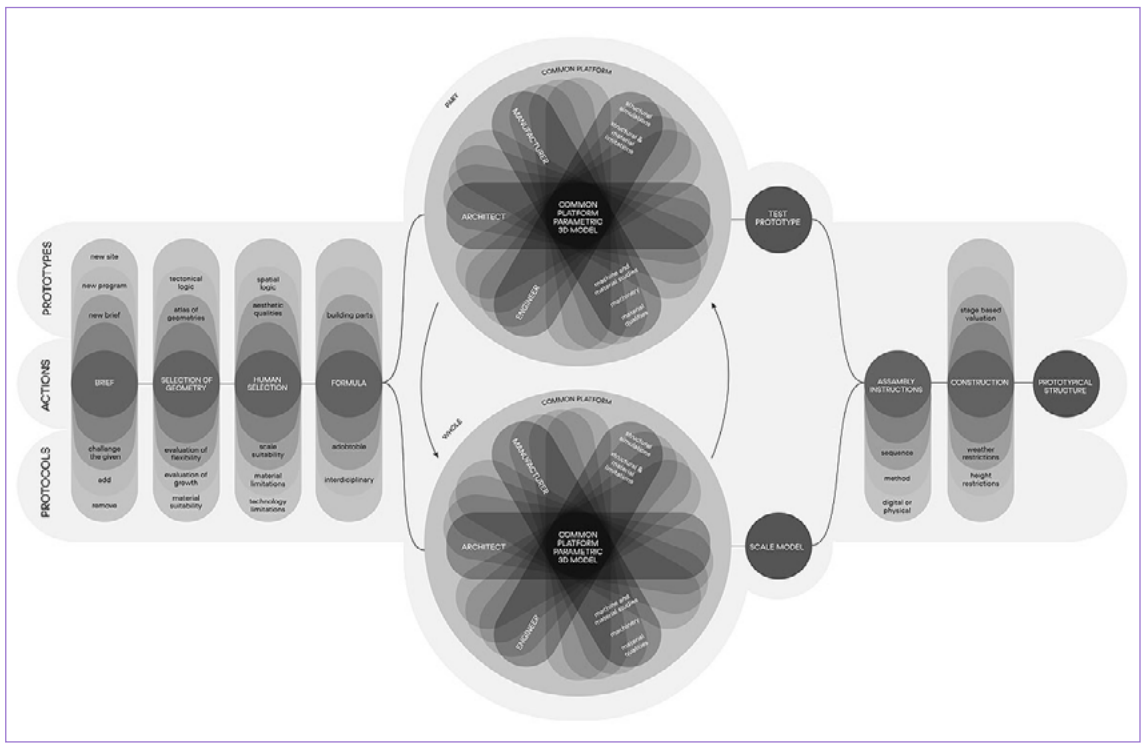
This PhD presents a practice-based, yet design-driven, body of work examining the projects, processes, techniques and concepts developed and employed during the past five years by PART (Practice for Architecture, Research and Theory). This practice is to be understood in the context of Estonia regaining its independence in 1991, an event that has enabled practitioners to bring various practices back to the table. The methodology of workflow analysis has enabled a new understanding of how we at PART engage in design processes and how specific tectonics have emerged from my work. The structure of this thesis is oriented by two main

tectonic logics in the PART projects – aggregational and somatic – which inform the specific trajectories of the various example projects.

The growing integration of digital technologies and technical innovation in design processes and fabrication methods[2] has provided opportunities for non-standardised and customised architecture (Carpo 2011). However, our practice development has shown that bespoke solutions are more time and energy consuming than those envisioned by computation-led construction, making them inappropriate for large-scale construction projects. This notion is guiding contemporary architecture towards what I call somatic modularity – discrete design systems and unified building blocks. Some of the key projects of PART, which are described here in chapters on bespoke (III), aggregational (IV) and somatic modularity (V), show the shift away from bespoke (2015–2016) toward modulated, repetitional solutions (2017–2018), and from skeletal to blocks (2018–...).

1.1.1 Collaborative workflow

The proposed collaborative workflow of design, construction and implementation processes, takes account of fluctuating design protocols and defines the interrelationship between applied methodology and architectural design intention. This method can also be applied to larger-scale projects, facilitating the production intermediate prototypes and informing the shared platform with looping protocols. It is also hoped that the introduction of looping design and construction protocols would reduce the energy used in construction and design processes. Architects, engineers and fabricators now have more tools than ever before to assist in the design and construction of detail comprehensive structures.



Collaborative part-to-whole workflow diagram, including architects, engineers and timber house manufacturers.

2 For example, in cooperation models, chain management, the use of sustainable materials and innovations in construction.

1.1.2 Material information

Current tendencies in material and technological innovation (Ritter 2006) enable certain spatial changes in relatable scale. Automated technological implementation allows for more flexible design content such as the use of timber, while also gaining efficiency and sustainability in production. My research also examines innovative cooperation models for timber construction with regards to digital processes in design and fabrication. More specifically, construction should reflect the current aesthetic, ethical and social values. If take care to understand the growing demands of the present epoch and orient our thinking clearly towards a sustainable future, we find ourselves confronted by greater challenges even than culture and economics: the social and ecological. New ways of designing and constructing could be introduced that, through appropriate prototypes and protocols, are capable of taking these challenges into account.

1.2 Context

For almost a century, during the Soviet and immediate post-Soviet eras when timber production was not encouraged, few timber structures have been built. Owing mostly to the scarcity and little variety of building materials in Soviet times, generations have been raised without awareness of any connection between renewable materials and architecture. However, in recent years the evolution of wood treatments, such as fire protection and moisture proofing, and structural improvements in glulam, have reduced the material restrictions on building and opened up countless new possibilities in construction.

For Estonians, wood is the principal renewable natural resource, yet the modern urban population has become estranged from this material. Luckily, larger Estonian cities and towns still retain districts of century-old wooden architecture. Although new wooden buildings make up a marginal part of local architecture, logging has not decreased. In fact, 91% of timber not used for power or heat generation is exported[3] – for use in Alpine log homes or Central European backyard saunas. In this regard, Estonia has become an exporter of a cheap commodity, rather than of value-added design.

Despite Estonia's long history of timber construction, renewed focus on the material should not be backward looking. Novel prospects, including advanced timber-manufacturing machinery, new computational tools for material optimisation and structural analysis (e.g. algorithmic modelling) and above all the ability to generate design strategies for new spatial qualities, can provide dataminded novel tectonics.[4] Local wooden-house manufacturers, digitally skilled architects and engineers, are aiming to collaborate around a common digital platform in order to achieve more efficient, flexible and structurally-intelligent architecture.

2. Contemporary architecture dilemmas

Today, the world is haunted by two spectres that will determine the future of construction and architecture: climate change and automation (Frase 2016). The first spectre, climate change and the increasing CO2 emissions in the construction industry, requires that we review critically the existing discourse. The second promises new opportunities for stronger collaboration in automated workflows, and whereby natural, organic materials and adaptive geometry may be introduced.

Construction should reflect the current state-of-the-art and social values. By accepting the demands of the epoch and orienting our consciousness towards the threshold of a new age, we will need to confront more challenging topics than culture and economics, and thereby ensure that ecological and social values become essential elements of our architecture. To achieve this, new ways of designing and constructing in automated workflow should be introduced.

2.1 Ecological damage

Human carbon emissions are warming the atmosphere, accelerating climate change. We must therefore develop more environmentally sustainable forms of construction. This thesis proposes ways of cutting emissions throughout the whole lifespan of a building, from construction through to demolition, including finishing works and maintenance.

3 In 2014, 90.8% of timber was exported. Source: puuinfo.ee
4 That is, using computational strategies to provide new geometric outputs.

Emissions produced by our using buildings following construction account for over 80% of the total CO2 emissions related to construction generally. Within the process of construction, the manufacture of construction products and materials accounts for the largest source of emissions.[5] Therefore, designers can make very significant decisions in defining bioclimatic design and establishing future lines, including selecting construction materials with low environmental impact.

Both design and construction materials are closely interrelated, each depending upon the other. The success of the design depends on the way the construction materials are selected and must be used (González and García Navarro 2006). Nonetheless, materials and fabrication methods are often not included in the workflow of design. This aspect of the contemporary art of construction should be changed, radically.

2.2 Automated industries

The construction industry is one of the least automated industries in the world, yet automated technologies are a large part of our everyday lives. The digital economy – driven by lean economic platforms built on artificial intelligence and machine-learning algorithms – plays an important role in our engagement with the built environment, from Airbnb to Uber and WeWork. This 'automation gap' between how we produce our built environment and how we live and work is the wider context within which this thesis is positioned.

This thesis aims to shed light on how automated technologies can be used to understand, analyse and communicate, to better enable collaborative work. Further, it will consider engagement with the economics, infrastructure and networks of Estonia's digital economy and its relationship to the increasing financialisation of the built environment.

Automation of the timber construction industry has huge potential for an increase in scale from small buildings to urban multi-storey houses. Knowledge of pre-made modular elements, quick assembly techniques and digitally-generated workflows already exists, but it is not currently being applied locally.

3. Grammar

The built environment continues to adopt what is effectively an international style, whereby subjective, ethical, spiritual, and philosophical concerns are suppressed in favour of utilitarian factors such as economics and the standardisation of materials, and a universal aesthetic understanding. According to Jacobus Johannes Pieter Oud (1918), in this context the modern architect must therefore become both technically knowledgeable (or at least have a clear understanding of modern building techniques) and have a very broad awareness of social factors. For this reason, interest in particular, context-driven design begins with the workflow itself – influenced by materials, fabrication methods and the participant collaborators themselves – and with the production systems that largely determine the grammar of forms, and are in turn descended from the digital protocols and physical prototypes of the process.

The research at PART focuses primarily on design methods, the experiments thus far should be understood as research into design methodology rather than into production and manufacturing or the engineering challenges of manufacturing. By repurposing industrial machines to creating complex, adaptive and structurally-intelligent architecture we may yet develop an architecture that will fully supersede the modernist physical space of standardised precast concrete.

3.1 Relatable scale

In the context of London's post war rebuilding programme, the Smithsons' competition entry for the Golden Lane housing estate (1952)[6] stated that communities needed to be "built up from a hierarchy of associational elements" or "appreciated units". By

5 IGT Report. Estimating the amount of CO2 emissions that the construction industry can influence. Supporting material for the Low Carbon Construction.

6 http://www.grids-blog.com/wordpress/plan-of-the-month-smithsons-golden-lane-project-1952/

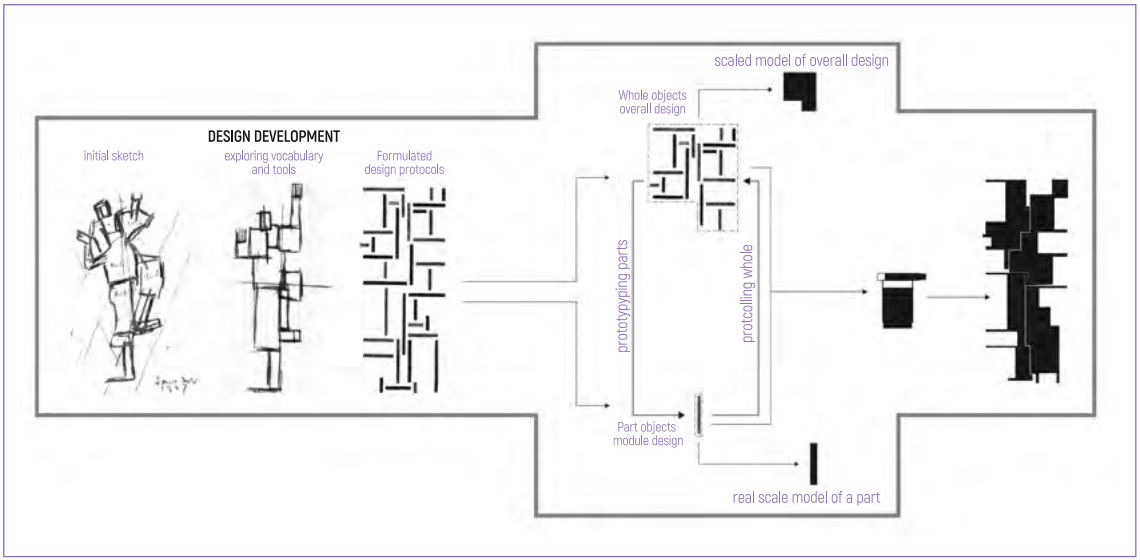
continuing the Smithson's ambition of returning the urban environment to a recognisable scale, PART aims to reengage citizens with the physical world.[7] Indeed, the use of repetitional modular elements and joinery, and prototyping throughout the design process at 1:1 scale, have become essential parts of the PART design methodology. By using discrete, small-scale building components, larger-scale buildings may thus become aggregated forms of user-sized elements.

By working with modularity and aggregational tectonic methods, the ways in which we put things together comes to define the parameters of the resulting architecture. By utilising a method of prototyping and engaging engineers and fabricators throughout the design process, we are able to develop a more integrated way of designing and in closer collaboration with the materials and processes of fabrication. Prototypes thus become the physical manifestation of the protocols that have been applied in the design process so far and an essential part of the collaborative workflow.

3.2 Abstract systems

With regard to artistic research, it is necessary to review the historical precedents for systems of modular construction. I am fascinated by Theo van Doesburg's "Russian Dance" painting, in which the artist redrew an initial sketch with increasing degrees of abstraction using repetitional elements, and created new movement in art and architecture. Each stage of abstraction emerges as a step forward in understanding the parts, which become increasingly simple as the process of abstraction progress. While it may seem that the artistic movement of Neoplasticism that followed from van Doesburg's work placed a burden of extreme limitations on artists, according to Piet Mondrian (and contrary to what the painted diagrams may suggest) those limitations in fact allowed a tremendous range of expression.

The marriage of abstraction and Neoplasticism has enabled me to create a workflow diagram that has become the skeleton from which the very chaotic nature of design may be hung. The underlaying



From Detail to Whole. Hermeneutic Circle of a Russian Dance, 2019.

7 Illustrated by its timber folly projects and writings published in the Estonian cultural newspaper *Sirp*. For example: https://www.sirp.ee/s1-artiklid/arhitektuur/ruumi-materiaalne-intelligentsus/

computer programme assists me in getting into the ecology of making, defining the interactions and environment of the participants. From sampling particular slivers or slender fragment of a construction scene, I can then go on to tackle much bigger ecologies. The integration of economy, politics and larger scale ecology in a synthesis enable a signature design to emerge, aware of its own context, material possibilities and capabilities of making. The more abstract the system, the more flexibility is provided for interaction and use.

3.3 Automated workflows

Over the past few decades, digital fabrication processes have been gaining momentum in the field of architecture and design. Some would even go as far as to say that they are gradually becoming the new mainstream, as Greg Lynn wrote in his "Robolog" special issue of Log (2017). However, the automation of design processes is far more complex (and may seem impossible), requiring stronger collaboration between all participants during the planning phase and around a common platform.

Our world is now pervaded by complex systems, from social media to algorithms suggesting what we should buy, listen to or read, and this has given rise to a popular understanding that authorship has significantly changed. Open source, crowd-sourcing and notions of collective intelligence have undermined the tradition of the individual author and formed a new understanding of distributed authorship.[8] In an era when architects are increasingly able to define their own tools, formulae, scripts and assembly diagrams, and are able to integrate with interdisciplinary participants, they are also able to create works that are closer than ever to their initial idea, and to a higher quality of detail.

As Achim Menges and Maria Yabloina have argued, new and automated workflows could result in novel spatial qualities: while the construction industry is racing to increase the efficiency of existing processes through automation of work in conventional construction environments, the field of architectural research is implementing robotic technology in order to discover new materials, fabrication methods and ultimately a new design space. By understanding how automated operations and actions are instrumentalised through these processes of engagement, complexity and collaboration, we can also understand our body of work so far; and by analytic evaluation of tectonic and aesthetic qualities, we can better evaluate the outcome of these processes.

3.3.1 Readable protocols

Given the extensive amount of information involved in aggregated complex geometries, protocols are becoming an essential part of the architectural design process. Significantly, it is not the final product that is the most important element, but the way in which that product is reached. Workflow protocols may become the defining procedural codes – a set of rules governing the transmission of data between stages. Algorithmic workflow is a nest of such protocols, providing a definitive framework of changes and connections between tools, collaborators and techniques. The proposed diagram becomes a skeleton onto which the very chaotic nature of design is being hung.

3.3.2 Tangible prototypes

A prototype can be an archetypical example of the means of making, but it should also embed the material means of construction. If we aim to construct with sustainable materials at the urban scale, we will then find opportunities to make far wider and greater use of renewable materials such as timber. By utilising an automated workflow and common platform between all engineering participants, we can better support construction that uses irregular (natural, organic) materials and geometries. With a parametric model, all participants can introduce design, material and fabrication protocols into the workflow, enabling the generation of more precise prototypes of protocols. As we engage with engineers at the various stages of the workflow, each stage having unique material qualities and live geometry, we can achieve a looping workflow capable of remaining true to the original design.

8 Distributed authorship in architecture and its analogy to Web 2.0 concepts are discussed by Mario Carpo in his essay 'Digital Indeterminism' (2013).

4. Emergence

Our projects show various scales of investigation, varying from furniture to infrastructure. Parametric design tools and a common design platform (Rhinoceros, Grasshopper), which allow engineers and architects to work in the same model, have helped create highly complex and performative architectural forms without compromising on the speed and cost of production. The fourth dimension in architecture is time – if you can make custom solutions more or less as time-efficient as standardised ones, the industry will be willing to adapt. In the examples presented in this research, the Body Building Installation (built for Tallinn Architecture Biennale 2015) required precisely the same quantity of timber elements and production time as a small family house (80m2), but with the advantage of allowing greater spans, height, cantilevers, etc. Further, the spatial qualities – fluid and curvaceous – have helped the public to understand the many possibilities made available by this approach. Most striking of all is the fact that the Estonian forests would require just one minute to produce all of the material used in this installation (2015).

We argue that, compared to traditional craftsmanship, digital craftsmanship in the techno-cultural environment of Estonia[9] offers more opportunities in terms of speed, building scale and complexity of form. We should not regard the properties of building materials in isolation, but rather embed them in the design process. Our investigations vary from light, transparency and the bending capacities of plywood to civil projects such as pedestrian tunnels and electricity pylons. This kind of experimental approach, having no precursors, has meant that demonstration prototypes – installations used to test particular methods – play an essential role in our daily practice.

Project example for a variable structure. Rheological Formation. The form of the installation appears dominant but consists of approximately 500 non-repetitive elements. PART, 2017.

Therefore, through the intermarriage of computational and physical space, we can create familiar yet complex spatial encounters that combine traditional materials with current technologies and having inherent aesthetics.

4.1 Bespoke structures

For years, our design goals involved exploring the limits and possibilities of the Estonian timber industry by creating installations showcasing the capacities of digital technology with variable non-repetitional elements. The initial idea was prompted by our understanding that the five-axis robots already in use in manufacturing industries are capable of far more complex task than they are commonly employed to perform. With installations like Body Building Installation, Rheological Formation and Soundwaves, we set out to investigate the potential of digital craftsmanship, arguing that digital technologies would enable non-standardised construction with irregular elements to be performed with the same efficiency as with identical, repetitive elements.

Even if that argument about production time was true in most cases, assembly times became significantly longer in proportion to the quantity of irregular pieces. When the projects were made – using a cheap/non-commercial workforce (students, volunteers, friends, ourselves) – it became clear that the methods would not all be translatable into the construction industry. Following this experience we understood that the design projects we intended to involve vector fields and high curvatures would needed to be revised, from the overall scheme through to the individual elements.

9 President Toomas Hendrik Ilves claims to have in the mid-90s "reverse-engineered" Jeremy Rifkin's *The End of Work*, the 1995 bestseller arguing that information technology would undermine large-scale industrial production. What he calls his "backward reading" of Rifkin led him to recognise the importance of Estonia's miniature physical size in creating a substantial post-industrial economy, where a small, tightly knit hi-tech workforce of perpetually pivoting entrepreneurs could reinvent Estonia as the original startup nation.

4.2 Aggregational structures

In recent years our research has been moving towards standardisation and repetition – using elements that decrease the time of assembly, but with less regulated methods of construction. Examples included installations such as Urban Jungle, Here and Elsewhere and Digital Thicket. However, the system we used required multiple additional layers of articulated elements, so that time efficiency diminished. Our 'Eureka!' moment was reached when we realised that the solution to a more efficient construction overall was in finding solutions to the detail of elements. Thus the importance of the relationship between parts grew and the idea of translating certain efficiencies at the scale of pixels, or modules, led to the creation of new architectural artefacts and again to the revision of the repeating elements.

Project example of a repeating element structure. 18m high green garden in T1 shopping mall. Completed 2018. PART.

Hans-Georg Gadamer (1998) reconceptualised the hermeneutic circle as an iterative process through which a new understanding of a whole is developed by means of exploring the details of its existence. Taking this idea as a starting point, the interplay between the building part and the building whole must be analysed: in order to understand the whole, one needs to know the detail. Thus the science of interpretation, or hermeneutics, plays a role in understanding the architectural whole.

4.3 Somatic modularity

Somatic modular structures are the focus of PART's ongoing projects. In these structures, each part includes necessary elements that would usually be inserted into the building in specific layers. Somatic structures are closed modules which, in addition to structural qualities, include space dividing and membranous qualities, and which also rely strongly on discrete syntax. Discrete construction systems are generally dry and prefabricated, meaning that they can be constructed more quickly and with greater precision (Knaack 2012). The main interest in the automation of the building industry lies in the promise of increased speed, simplicity and reduced human labour on the building site (Retsin 2016).

One of the main constraints with large-scale additive manufacturing is undoubtedly the speed. Moreover, assembly-based processes have the advantages that the components for assembly can be composed of multiple materials; for example, combining timber with metal joinery. The proposed methodology has the potential to provide new opportunities for architects, engineers and fabricators to collaborate, and to enable increased use of the available algorithmic and simulation tools with the eventual goal of robotic fabrication.

Example project for somatic modularity. Multi-storey apartment building in Tallinn. Schematic design. PART, 2018.

5. Conclusion

Estonia, due to its very small size and flexible enterprises, is a perfect testing ground for industrial collaboration. The markets continue to grow rapidly, while competition is intense. Consequently, wooden house manufacturers are looking for ways to stand out, innovate and be sustainable.

These prototypes and experimental pavilions, aimed at introducing new construction methodologies, offer the potential to enable the timber industry to find new solutions in large-scale construction projects. By thinking within material parameters and in terms of modularity, we may be able to return architecture to a relatable scale and construct a more humane built environment. To achieve this, modular somatic structures would rely on maximising abstraction and focusing on those details that relate the parts to the whole.

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Sille Pihlak

is an architect and laureate of the Young Architect Award 2017. She studied at the Southern California Institute of Architecture in the US and graduated from the University of Applied Arts Vienna, in Austria. She holds a bachelor degree in interior architecture and is currently a PhD fellow and junior researcher at the Estonian Academy of Arts. She has constructed various scale installations, designed interiors and won several prizes at multiple architecture and planning competitions as well as published a number of critical essays on sustainable architecture and urbanism since 2015. As a believer in the "inevitable sustainability of architecture", she is one of the key initiators of urbanizing and automating timber architecture in Estonia. She founded the architectural office PART with Siim Tuksam in 2015 and was previously a trainee at Morphosis Architects Los Angeles and CoopHimmelb(l)au Vienna. She has been editor of the architecture section of the cultural monthly newspaper Müürileht. In 2016, she inaugurated the environmental architecture studio at the Estonian Academy of Arts, and since then has been co-curator of the Open Lecture Series and participated in various government initiated expert groups.

FRESH FROM THE FOREST: RAW, DISCRETE AND FULLY AUTOMATED

Gilles Retsin
Bartlett School of Architecture,
University College London[1]

Abstract

Emerging new platforms combine timber with automation, prefabrication and end-to-end integration in an attempt to disrupt the construction industry. While these efforts contribute to the renewal of an often outdated industry and have the potential to contribute to a more ecologically responsible built environment, there are also a number of potential risks attached to their centralised approach to automation. Although architecture has a long history of engagement with digital technologies, it has yet to fully understand and theorise the rapid changes implied by automation and the digital economy which underlie these new platforms. This paper proposes to shift from the notions of "digital design" and "digital fabrication" to the notion of automation, to emphasise the social, political and economic implications of digital technologies. A framework of automation moreover allows us to connect with aspects of the digital economy, which is arguably the aspect of the digital that most significantly impacts the world and our cities. On an architectural level, it draws a historic continuity with mechanisation, bypassing postmodernism and the early digital's dialectic relation with the modernist project.

The work presented in this paper acknowledges the new timber platforms argument for timber as a material with disruptive capacities. Timber currently already has a high degree of automation throughout its entire production chain. Forests are managed digitally, continuously responding to the global demands and logistics of sustainable timber production. However, the paper proposes an alternative, distributed and more open-ended framework for timber platforms, based on the combination of discrete architectural parts with automation. This so-called discrete paradigm builds on a computational understanding of parts as function agnostic, serialised building blocks that can be digitally assembled into functional buildings. These building blocks are manufactured by the computer-controlled processing of widely available, two-dimensional base materials such as plywood or mass-timber sheets. Projects such as the Tallinn Architecture Biennale Installation (2017) and the Nuremberg Concert Hall (2018) explore this context of automated discrete timber and its architectural, technical and economic consequences for the production of housing and the building industry at large.

Keywords: automation, computation, digital economy, platforms, housing, robotics, timber

1 Correspondence: g.retsin@ucl.ac.uk

1. Introduction

1.1 The 90s

Whereas architects initially speculated on the digital as something merely virtual, today, even the most banal aspects of our lives are reconfigured by digital platforms. Arguably, one of the driving forces behind this proliferation of digital technology is automation. In continuation with 19th century industrialisation and 20th century mechanisation, automation is driven by the economic desire for ever more efficient modes of production (Noble 1984). Just as with industrialisation, automation is therefore deeply connected to social, political and economic questions (Noble 1984). The futuristic Kiva robots in the Amazon warehouse cannot be understood in isolation from the gig-worker on a precarious zero-hours contract. Post-Capitalism, Post-Work society, and Universal Basic Income are all responses triggered by the ever-increasing impact of automation on our daily lives. In the early 20th century, mechanisation and new means of production were actively debated in architecture and art, from Walter Benjamin's *Art in the Age of Mechanical Reproduction* (1935) to Siegfried Giedion's *Mechanisation takes Command* (1948) and Le Corbusier's *Towards a New Architecture* (1927), and so is the political philosophy of accellerationism today in art discourse (Beech 2019). However, in architecture, emerging digital technologies were initially – in the last two decades at least – not considered as "means of production". From the nineties onwards, digital technologies provoked an incredible exploration of new notions of space and aesthetics, but were rarely inscribed in an economic or social context. In hindsight, we could speculate on the why and how of this limited reading. One explanation could be the frenzied economic climate preceding the 2008 financial crash. Perhaps a less charged account could argue that digital technologies before the 2008 financial crisis were still relatively disconnected from large economic issues. Sure, there was a dot-com bubble, but there was not yet a substantial "digital economy" – at least not acting in the built environment. Moreover, in the absence of the yet-to-emerge platform economics, social media and smartphones, the digital was not yet as pervasive as today.

1.2 Post-2008

The economic optimism of the late nineties was abruptly shelved with the financial crash of 2008. Along with it, the early digital architecture experiment was partially put into administration and evacuated from the cultural scene to academic research programmes, where they went on to be highly successful, but relatively isolated from larger discussions. Ironically, architecture's partial retreat from the digital coincided with the boom of the digital economy, social media and the explosive global dominance of Big Tech. By the time that unicorns were no longer just legendary creatures but also billion-dollar-valued startups, architectural discourse had either completely isolated itself from the digital or not developed beyond the discursive boundaries initialised before the crisis. Today, digital platforms such as Airbnb are actively reconfiguring our cities and mode of living, while Alphabet's Sidewalk Labs is planning an entire neighbourhood in Toronto. Companies such as Katerra attempt to overhaul traditional construction and architecture with venture capital-backed prefabrication, purchasing multiple architecture offices along the way, such as the celebrated Vancouver based Michael Green Architects. Novel hybrids of real-estate development, lifestyle-brands cum platforms such as the Collective, are developing shared-living communities around the world, shaping new forms of domesticity. This new situation brings a sense of urgency to architectural discourse to reconsider the digital as fundamental for the discipline to remain relevant.

2. Straight from the forest

2.1 Slices

While timber is an obvious choice in the context of the global climate emergency, it also has the potential to transform construction into an automated industry. Previously mentioned platforms such as Katerra and Sidewalk Labs base their entire production chain on the use of timber. This does not come as a surprise as timber production today is already largely industrialised and automated. Responding to the increasing global demand for timber, Sweden's total area of forest has increased over 70% in the last decades. To manage these larger and larger areas, the forestry

industry has heavily invested in end-to-end automation. Forests are now managed digitally, with every tree tracked and stored in databases, its lifetime monitored closely until the day it is finally harvested. Advanced computer vision technologies are developed to analyse forests, segment trees from point-clouds, and model production.

Once harvested, automated machines dissect trees into precise slices and glue them back together into standardised sheets with EN, DIN and ISO standards labels attached. The vast difference and unpredictability of the natural forest is reduced to dimensional tolerances of a millimetre. Whereas traditional timber relied on limited lengths and dimensions of lumber, engineered timber products can now be produced in lengths at wish. These sheets and panels can then be computed, engineered, insured and traded, ultimately becoming standard assets in BIM-software and catalogues. After being shipped, these can be cut with relatively simple machines into customised building elements, in places far away from the original forest.

2.2 Parts

The automated, short production chain advocated by companies such as Katerra and other timber prefabricators is based on a what is known as a "kit of parts" approach. A prefabricated catalogue of parts such as floor cassettes, columns or bathroom units is combined into a complete building. Timber disruptors typically offer end-to-end integration – providing everything from base materials to design, on-site delivery and facility management. Katerra argues that their catalogue of parts establishes choice: unlike the dreaded cookie cutter prefabrication of the 1960s, building designs can now be "mass customised" to the clients wishes (Katerra n.d.). Previously, the term mass customisation was often used by the early generation digital architects to describe the process of creating non-standard forms from thousands of small components. In this context, the notion of mass customisation is, however, very different from the early digital one: this is not a mass customisation of form, where every building component is different, but one based on assembly, from serialised and standardised elements. Rather than experimental form-finding and generative coding, Katerra's BIM-like software allows them to design and customise buildings from their catalogue of parts.

2.3 Platforms

These emerging timber platforms arguably contribute substantially to a desperately needed change in construction and building culture today, but also raise some pressing questions. From a socio-economic point of view, and under pressure from vast amounts of venture capital, these platforms seek to establish a centralised model that ultimately wants to create quasi monopolies similar to the likes of Uber and Airbnb. As these platforms are end-to-end integrated, there are significant consequences for the business models of non-integrated architects and contractors (Sanchez 2018). In this context, it is worth considering Nick Srnicek's (2017) writing on Platform Capitalism, which explains how the initial premise of the digital as a form of economy with the inherent possibility to democratise production ends up with powerful platform monopolies. In architectural discourse, Jose Sanchez has critiqued this closed box model of vertical integration, arguing that new platforms should be more distributed and empowering to users, citing Trevor Schol's model of Platform Cooperativism as an example (Sanchez 2018). However, this potential danger has to be further nuanced. At present, these emerging platforms are nowhere close to even a regional monopoly and actually contribute in disrupting the prevalent quasi-monopoly of large developers and contractors in a classic design-bid-build model (Claypool et al. 2019), which in most cases offer lower quality and less environmentally friendly products than their upcoming competitors. However, it is important to explore potential alternative models of more decentralised and open forms of automations, which could empower a larger ecology of designers, builders and future inhabitants.

2.4 Kit of parts

From a technical point of view, the new timber platforms are based on a standardised kit of parts approach, commonly associated with modernist prefabrication. This "simplified automation" (Bava 2020), with fixed hierarchies and types, severely limits the

200M Housing Block. Gilles Retsin, 2019.

amount of difference that can be achieved, putting into doubt the earlier promise of mass customisation and design freedom. While this approach significantly reduces the amount of parts in the production chain, thus increasing efficiency, it is not per se a novel approach, nor does it fundamentally disrupt construction as we know it. The proposed production chain remains fundamentally discontinuous and requires scale and centralisation to create the ultimate, optimised kit of parts. From an architectural perspective, the proposed model erodes the agency of architecture as a discipline and a form of knowledge beyond mere logistics. Architecture becomes a service at the hands of the platform, with the task of making the building product more efficient and giving it marketable visual appeal. For sure, many of the building

prototypes promised by the timber platforms are of high quality, but in what way do they contribute to architecture as a cultural discipline? The role of the architect is reduced to tinkering with an established catalogue of parts, within the constraints of the platform. This critique is not unique to the new construction platforms, also other system-based approaches such as the open source WikiHouse and BuildX initiatives run the risk of reducing architecture to a logistic endeavour, albeit with a more social purpose.

From a domestic point of view, the timber platforms turn "housing" into a mere commodity, the home becomes a facility to be inhabited, an asset to be traded. This critique again has to be nuanced, as this is currently already the case with traditional developers and the housing market in general. The majority of housing is already a market commodity, the unique, architect designed home – with a more metaphysical dimension – is in many countries a rare privilege for the few who can afford it.

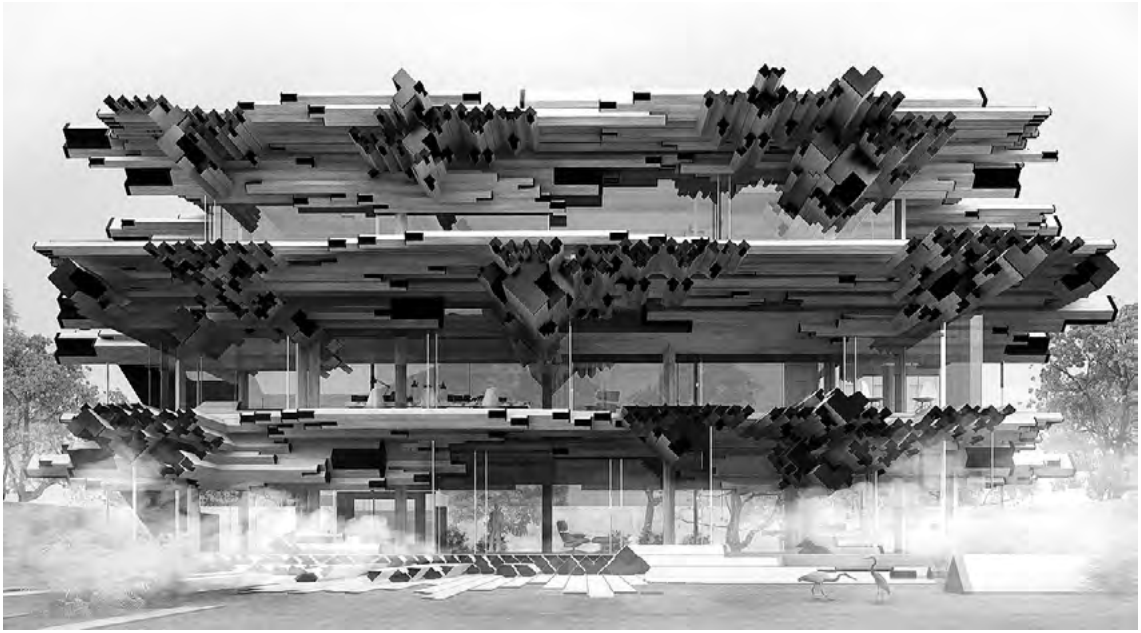
2.5 Discrete

An emerging body of work referred to as "Discrete" in architectural discourse, advances an architectural paradigm that emphasises the combination of automation and parts (Claypool 2019). However, in a crucial difference to the new timber platforms, the Discrete argues for a much more open, agile, decentralised and architectural platform. Unlike the modernist "kit of parts" approach, the Discrete approach starts from a digital understanding of parts as function agnostic, generic "building blocks" which through their combination and interaction can establish higher-level functionality – not dissimilar to the Centre for Bits and Atoms' Digital Materials (Gershenfeld et al. 2015). This approach emphasises the discrete nature of computation (Carpo 2014) and reframes architectural parts as voxel-like units (Morel 2011) that can be variably organised and programmed. A body of creative work has emerged by architects such as Jose Sanchez, Daniel Koehler, Rasa Navasaityte and Casey Rehm, which all in their own unique way develop new digital mereologies or organisations of parts. Bypassing the reductive kit of parts, the Discrete combines the efficiencies of modularity and prefabrication with complexity, variability and open-endedness. Buildings are developed on a "granular" level, increasing the resolution and space of possibilities. Moreover, this approach inherently leads to a short and continuous production chain, where assembly becomes a digital process of assembling repeating base elements, not dissimilar to additive manufacturing (Hiller 2009). Whether the elements are small or large, 3D-printed, assembled by robots, participant-users or human workers, this computational mode of assembly remains unchanged. The premise of the discrete is that efficiencies gained by automation create value which should be invested in architecture itself and its users. While some of the work emphasises more the architectural over aspects of democratisation and participation, it subscribes to a very different understanding of the build environment than the commodified vision put forward by the timber platforms. Architecture is understood as a complex cultural discipline, with aesthetic, social, political and economic implications and responsibilities.

3. Discrete automation

3.1 Timber building blocks

The Diamonds House, a 2015 project for a multi-family house in Belgium by Gilles Retsin Architecture, introduces the idea of building function agnostic, discrete building blocks from simple sheet timber materials. The house proposes a limited set of volumetric hollow elements, assembled from Laminated Veneer Lumber (LVL) sheets. These elements are then combined to establish higher-level organisations. Architectural features and functions emerge from the granular assembly of the building blocks, rather than being predefined by architectural or structural types such as the slab, beam, wall or cell. The building blocks are autonomous and pre-exist the specific instance of the built whole itself. The Diamonds House is therefore perpetually in-part-whole. The house does not exist as a one-off but could exist in parallel in endless granular variations. It allows the actual mass customisation of every instance, at the resolution of the part itself, while not requiring any additions to the production chain. This granular mass customisation is therefore only at an informational cost – the simple instruction and evaluation of where to position a specific element.

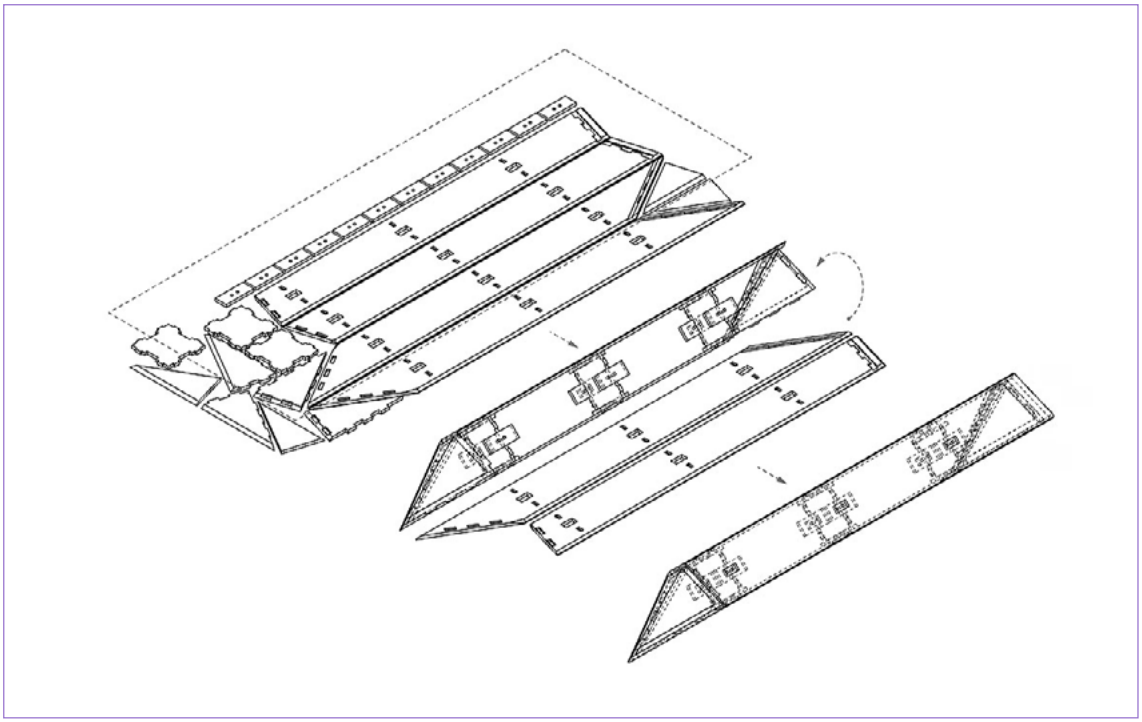


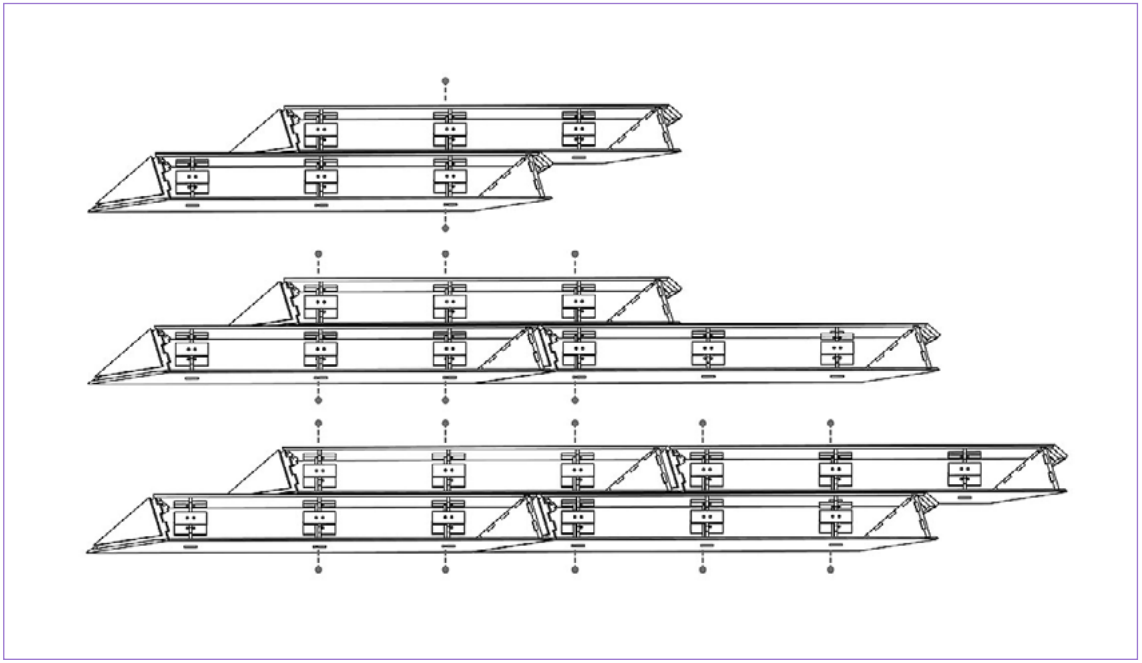
Diamonds House. Gilles Retsin, 2015.

Beyond tectonics, mereologies and material organisations, the liberation from predefined types and hierarchies results in endless new forms of domesticity, not bound to simple one-two-three bedroom catalogues. The domestic organisation of space is no longer a product of form-function dialectics, but enables exponential variation and freedom for interpretation by respective inhabitants. The same discrete building blocks can be used to construct shared-living spaces, open lofts, co-working spaces, traditional one-bedroom flats or back-garden pavilions. As parts can be reversed, engraved domestic visions and ideas are moreover no longer fixed in time. On an architectural level, the organisation of parts does not necessarily have to result in blurry-pixelated clouds that are now commonly associated with the discrete body of work. Parts could also be organised in different resolutions, with different levels of entropy, and varying ideologies in conversation with disciplinary obsessions such as figure-ground, poche's, subtractions, juxtapositions, chiffres, grids, or open-plans.

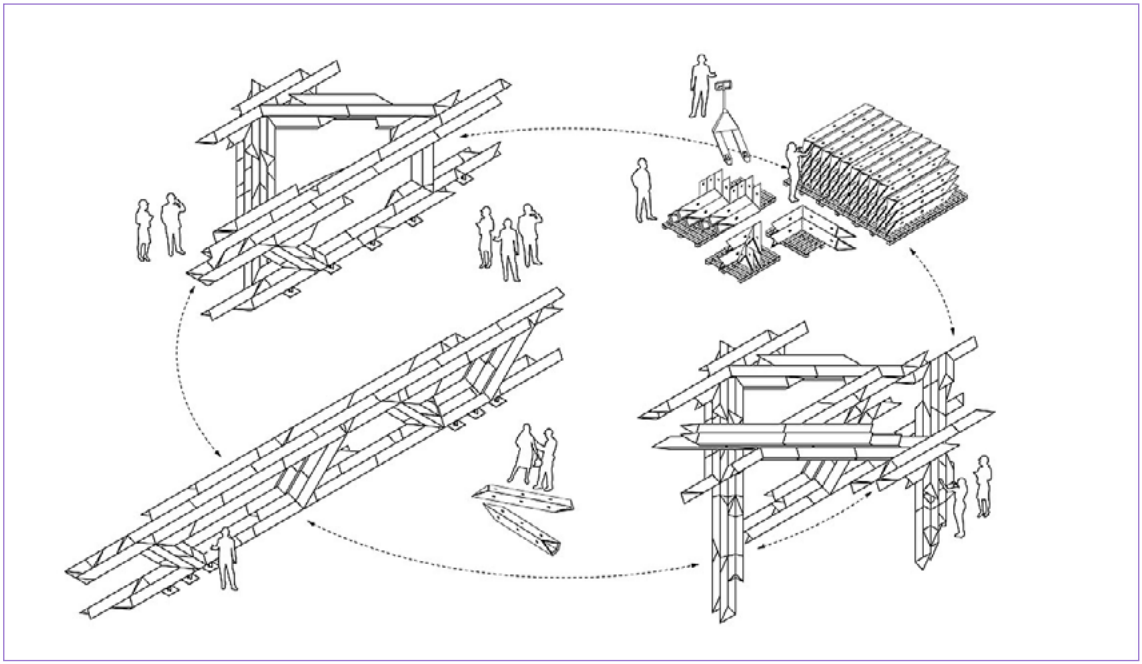
3.2 Prototypes

A series of 1:1 prototypes were constructed to evaluate and test the premise of the Diamond House. The first is an installation for the Tallinn Architecture Biennale (2017), which is conceived as an abstract fragment of a larger housing block. A family of discrete parts was developed, which can all be derived from a single sheet of 18mm plywood. A standard three-axis CNC machine is used for cutting. The part is designed as a box-beam like element, and an external structural skin with internal frames. These frames are notched in the skin and set out modular connectivity for post-tension rods that run laterally across elements. Unlike traditional post-tensioned structures, these threaded rods only act locally and are therefore in themselves discrete. While architecturally, the elements read longitudinally, the internal stiffening frames and post-tension rods form a continuous structure laterally. This results in a timber monolith composed of parts, which can subsequently be altered, reversed and re-assembled. The TAB installation advances the idea of a discrete granular architecture with endless possibilities of recombination. Assembly moves on from its association





TAB Installation. Gilles Retsin, 2017.

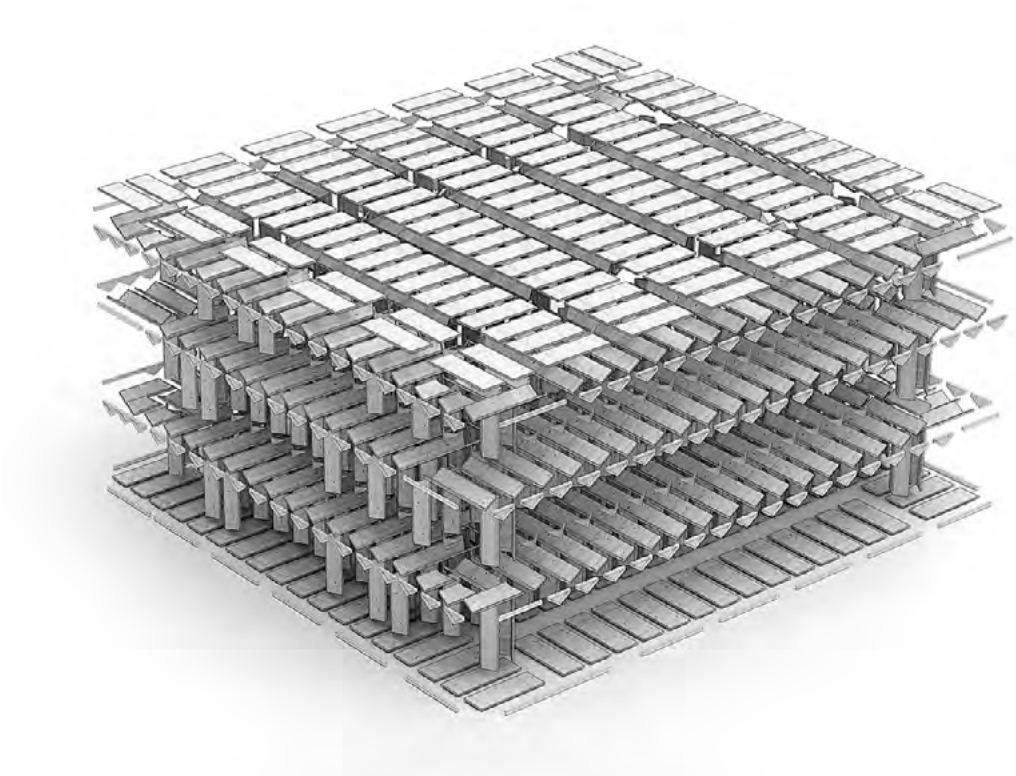


TAB Installation. Gilles Retsin, 2017.

TAB Installation. Gilles Retsin, 2017. Photo: NAARO.

with modernist notions of prefabrication and fixed part-hierarchies to become a digital process. Unlike the examples of digital materials, the parts are deliberately not regular space-filling polyhedra but are asymmetrical. This limits the amount of connection possibilities and granular variation, but on the other hand also establishes a quicker construction sequence and reduces the joints needed.

While Sanchez (2018) argues for non-architect users as active participants in the design process, the work discussed here remains firmly in the hands of architects as authors and unique specialists. By turning towards the monolithic, it even assigns more agency to the architect, resisting the continuous outsourcing of the discipline to specialist consultants. Driven by ever more accessible digital fabrication tools, this model moves in the direction of the architect-as-fabricator, as we know from Jean Prouve and Miguel Fissac.



Nuremberg Concert Hall. Gilles Retsin, Stephan Markus Albrecht, 2018.

3.3 Scaling up: Nuremberg Concert Hall

A competition proposal for the Nuremberg Concert Hall, with Stephan Markus Albrecht (2018) scales up the approach of discrete timber elements. Rather than plywood, Cross Laminated Timber (CLT) sheets are assembled into large, repeating elements with a hollow cross section that contain building services. To organise the hundreds of generic timber modules into a functional building, an algorithmic procedure was developed based on a so-called "voxel-space", or a volumetric pixel. An algorithm assembles digital v-shaped patterns into larger structural elements surrounding the functional programme of the concert hall. The voxels translate into repeating CLT plates, which then again form large modules that assemble into specific spatial patterns such as a wall, corner or ceiling. The resulting architectural space can again be understood as an engineered timber monolith, where walls, ceilings and columns do not exist as functional types but a single, repeating material operation structures the entire building.

The proposal for Nuremberg articulates itself as an apparently simple box-shaped massing; however, it can only really be understood as a series of autonomous parts, which are not derived from the whole and could repeat in other built instances. The project shows how the method, initially developed in plywood, can be scaled up to mass-timber without fundamental differences. At the same time, the plywood prototypes remain a good solution for smaller-scale structures such as house-extensions or single-family houses.

Nuremberg Concert Hall. Gilles Retsin, Stephan Markus Albrecht, 2018.

3.4 Primitive yet fully automated

Just as the first primitive dwellings were constructed from found materials – huts assembled from tree trunks or stones – this fully automated architecture is also directly extracted from the forest. Its extremely short production chain strips architecture from its layers of history, right down to its raw and primordial, monolithic state. A primitive log cabin is not a monolith, but still in conversation with its parts. The logs are recognisably present and remain to a certain extent autonomous from the whole. Preceding types and hierarchies, a single repeated operation constructs everything – not dissimilar to the examples of the projects in Tallinn and Nuremberg discussed earlier.

Contemporary architecture and construction rely heavily on an assembled, discontinuous layering of thousands of elements, parts and components. It can therefore be understood as the opposite of a monolith, which consists per definition of only "one". While this complicated layering is at the source of many inefficiencies, it also has architectural problems emerging from it. In many cases, the attempt to establish a consistent whole is rendered futile by the many parts that need to be organised. Enormous efforts have to be made in customising the parts to subjugate to the whole, with a time-intensive and expensive coordination process as a result. By making a limited number of large, autonomous parts, the digital discrete overcomes these logistical problems. The resulting architectural quality is that of a strange contradiction: while fundamentally discrete, it appears phenomenologically continuous. It has a monolithic

quality while remaining an assembly of autonomous parts. Consistent and coherent, yet made of parts, this discrete architecture establishes an experience of a "whole" without a whole.

The digital discrete is therefore a continuous – even organic – form of architectural assembly. This has economic, technical and architectural consequences. Economically, the production chain loses its discontinuities and becomes therefore easier to technically automate and integrate. The work breaks the age-old form-function logic, bypasses the modernist kit of parts, and establishes a new kind of architectural syntax.

4. Conclusion

This paper has outlined a specific context of architecture in relation to the digital, before and after 2008. It urges architects to take into consideration the recent developments of emerging timber construction platforms. It proposes a more open-ended platform, based on discrete building blocks, that has economic, social and architectural consequences. The proposed platform changes from a modernist kit of parts to a digital approach to parts as recombinable voxels. This allows for a higher degree of automation and a shorter production chain, which in turn enables more actors to participate in the production of our built environment. Rather than a capital intensive, large-scale, centralised platform, the proposed model enables an ecology of small-scale entities across architecture, construction and users. The dissolution from a fixed kit of parts to a more granular approach opens up more possibilities to experiment with new modes of domesticity and living, while also emphasising the importance of architecture as a form of cultural production and the significance of housing as more than a commodity or facility.

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Gilles Retsin

originally from Bruges, Belgium, is an architect and designer now living in London. He has studied architecture in Belgium, Chile and the UK, where he graduated from the Architectural Association. His design work and critical discourse has been internationally recognised through awards, lectures and exhibitions at major cultural institutions such as the Museum of Art and Design in New York, the Royal Academy and the Centre Pompidou in Paris. Retsin won 1st place in the competition for the main installation of the Tallinn Architecture Biennale. He has also qualified with his proposals for the Budapest New National Gallery and concert hall in Nuremberg. He recently edited an issue of *Architectural Design* (AD) on the Discrete and has co-edited *Robotic Building: Architecture in the Age of Automation*, with Detail Verlag. Retsin is Programme Director of the M.Arch Architectural Design at the Bartlett School of Architecture, University College London. He is also co-founder of the UCL Design Computation Lab, which conducts high profile research into new design and fabrication technologies. He worked as a project architect with Christian Kerez in Zurich, before founding Gilles Retsin Architecture.

PANEL DISCUSSION – CONFERENCE "SPACE AND DIGITAL REALITY"

Jüri Soolep (JS), Antoine Picon (AP),
Mario Carpo (MC), Roland Snooks (RS),
Gilles Retsin (GR), Roemer van Toorn (RvT),
Adria Carbonell (AC), Annarita Papeschi (AnP),
Dagmar Reinhardt (DR)

JS: Now the official part is over, so this is the more social part, also something that cannot be governed entirely so we do not know what will happen. The audience could easily become closer to slightly balance the undemocratic way of us having an oval table here and starting the discussion. It has been a fascinating day for me at least. I hope for everybody else as well.

We have had brutal computation. We have had swarm intelligence, design intentions. We have had atoms and bits. And in between, we have had everything else. So, I am really grateful, Antoine, that you produced the word *political* because it started in the morning also with *ideological*. So not to impose anything but I would say four words only and then try to open up the discussion. It is ideology, aesthetics, politics and ethics. Not necessarily in that order, but closely connected always to architecture. We cannot deny that there is *digital*, I dare not to say it with *reality*, but truly I believe there is an autonomous digital reality, which as we have understood today will fundamentally change things.

So, I would like to open up the discussion. What happens to architecture in this new world looking at these four words that really connect humans to architecture and building? And I would in a way give the floor to you guys who have been doing the keynotes to start with remarks and questions for each other. Then immediately I will open up the discussion here as well so we could go back to the questions and, well, ask the questions.

MC: You first.

AP: Okay, I will start with ideology. Architects necessarily have to deal with ideology if we define ideology as the number of ideas *et cetera* that we share in a given society and contribute to stabilizing it for the better and for the worse. So, architecture inevitably has to do with ideology. Architecture has also to do with the disruption at the margins of ideology. And one of my arguments was to say that architecture was political not only because it endorses ideology but because it disrupts it slightly. So, I have already done ideology and politics. What was the third – it was ethics – and …?

JS: Aesthetics. That is between ideology and politics.

AP: Aesthetics for me is a tricky question actually because I think aesthetics … I am deeply interested in aesthetics, but I think that aesthetics goes a step further than the beautiful as opposed to the ugly or the ugly as the new beautiful or whatever. Aesthetics is about meaningfulness. For me, the task of architecture is to suggest that this is a world in which humans have a place, which is not much but is enormous. It creates a human arena.

And with the last term, I will be provocative. I am not sure that architects are very ethical people. In the ordinary sense. Architects are ready to betray their mother, father and friends to get a building built. So, we all know that they are a bit tricky. But they have there again a kind of higher sense of ethics. Let me take an example from Le Corbusier. You know, there has been a lot said about Le Corbusier being a fascist *et cetera*. I think Le Corbusier was not a fascist for a very simple reason. He was ready to build for

whoever – Mussolini, the Soviets, you name it. But the Soviets actually – the only big building in the 1930s was for the Soviets. The thing that did not make him a fascist as compared to Speer is that he believed that everybody should be treated by the architect with dignity. And, for example, that the Villa Savoye, which I mentioned, not only does the Villa not look like a car, but there is the house of the gardener which is simpler *et cetera* but exquisitely designed. One of the things I believe about aesthetics is that actually every human being is entitled to architectural dignity. And that should be one of the tasks of the architect. I am done! I did it!

MC: Me? Who designed these chairs?

JS: Luckily, we do not know.

MC: Not one of you?

Audience: Väino Tamm. An Estonian interior architect. Why did you say that?

MC: They are not comfortable. [Laughter.] Anyway, to go back to your query, I am not particularly comfortable in dealing with politics and ideology because I am an old man. When I was a student we were still indoctrinated in my country, as in other countries, into thinking, which was evidently an ideological premise, that ideology and politics are over structures. What is the technical term in German? *Über-, über-* something. What would Karl Marx have written? Structure, overstructure, über-structure meaning …

AP: Superstructure.

MC: Superstructure in English, but does anyone remember the original in German?

AP: You know, we are in Estonia, so Karl Marx … [Laughter.]

MC: Some may not … We are the same generation I presume so probably you had to study that at school as I did.

AP: Yes. You know, I think a part of these guys were pretty much from the same generation.

MC: Anyway, politics, ideology, ethics, aesthetics … How did you say, overstructure? Superstructure. The structure is economics, cost, labour and I would add because it is critical today, the environment. So, in my opinion, having a direct confrontation as designers and technologists, as architects and urbanists with economics, costs, labour – the human factor, and the environment is our main inevitably inescapable challenge. This is where I think new technologies are our friend, not our foe. Because in each of these areas we can argue, but not everyone agrees that technological change can make this predicament easier to fix than it would be otherwise, meaning without technological upgrades. So, in this fight technology is our friend, not our foe. Next in the next query. Now you.

RS: Maybe I will pick up on that. So, you are obviously both saying that the most imperative question of our time as architects is one of sustainability. I mean you have both stated that at different times this afternoon.

AP: I did not say exactly that. I think that architecture has to recognise how important it is. That said, I do not think that architects should become sustainable engineers. That I do not believe.

RS: Because I would say that sustainability is not the most important imperative in terms of something that we should focus architecture on. It is something that we have no choice but to focus architecture on. It is something that is entirely inescapable. However, I do not think that it is necessarily interesting enough to drive architecture.

AP: I agree.

RS: So, I think we are talking about the same thing, but it can be easily misunderstood when you say that sustainability is the most important thing, therefore sustainability must ...

AP: No, to take a very simple metaphor, my argument is to say that sustainability is like the white page, but then you still have to take a pen and write a poem.

RS: Yes, exactly.

AP: But you need to write it on that page.

RS: Yeah and I would say as I said earlier today that it is the same with structure. I think all these issues are issues of building science. And obviously, sustainability is the most important one. Although, things like structure affect efficiency and therefore sustainability, but these are questions of building science not of what I think architecture really is, which is part of the humanities.

AP: Among my favourite sayings is since I was trained as an engineer I can allow myself to often say that if you want to save the world, be an engineer, but if you want to give meaning to the world, be an architect. Which is not the same business.

Q: Does this [microphone] work?

JS: No.

Q: Was that on purpose?

AP: Yeah, that is called democracy.

GR: Okay, because the panel agrees too much, I maybe want to add something about politics. Because I do think that politics are deeply engaged in architecture even not in a naive way. And, for example, I do think that the blobs in their apoliticalness are typically in the early brew. They only catered to questions that never had any kind of social implications. They worry about building, catering towards really big funky museums in Asia or in Dubai funded by oil money. That whole digital agenda that Mario called *the first digital turn* never took onboard an actual question about, for example, housing, right. Like housing – 90% of building stock was left out. That is a political decision that is saying essentially that we are catering for the liberal market. Our kind of funky shapes are not catering for people to kind of live, but they are kind of catering to marketing cities.

And I think there is a political decision in, for example, choosing your kind of battle as an architect. I think that it also relates deeply to aesthetics. I am throwing a ball to Roland here, for example. I think if you treat every design as a kind of something that is in a way unique and cannot be replicated, for example, along the streets or multiplied in an array almost of 40 by 40. There are some aesthetics that are made for multiplication and that are in a way not trying to be kind of the most exciting instance of architecture, but that are generally kind of exciting instances.

That is also kind of a political position. Like basically how much is a work replicable and not applicable, which embodies the idea of the city, which embodies also a democratic idea that the city is not composed of unique extreme moments of aesthetics, but that there is a general shared aesthetic that we all get, right? Which is the difference between a liberal model of difference and a model of difference that we find in the historic cities. In historic cities everyone inhabits roughly the same building. If you look at London or Paris, it is a serial repetition of the same moves with subtle differences in parts and certain classes of buildings. But none of these buildings want to talk about a very specific unique kind of moment of excitement, right? So, I think there is a very deep political stitching together all of these questions. I think it is so intrinsically embedded in how we practice as architects. And I think that is a political position.

AP: Gilles, two things for you. First, you are reinventing the modernist project. Second, if I was the devil I would take you on top of a hill and I would ask you if you had the choice of building a magnificent opera or housing for 10,000, or not 500, what would you choose?

GR: 10,000 I liked, I would choose 10,000 houses over the opera.

MC: Hannes Meyer would have chosen 10,000.

AP: Hannes Meyer, exactly, but we are back to the modern.

GR: But I mean, that is … I do not think it is that dialectic. Robin van den Akker wrote his manifesto called 'The Metamodernist Manifesto' which is basically saying we are not back in modernism and obviously I think that, I argue we are not back in modernism. It is just trying to say that the questions that we should tackle as architects can go beyond the kind of funky,

Panel discussion. Antoine Picon, Mario Carpo, Roland Snooks. Photo: Martin Siplane.

for instance. That does not mean that I want to be Hannes Meyer, which I think is an absolutely scary scenario …

RS: I do not think that it is … Look, I think that it is an interesting question, and yeah, I think that one of the differences between what you are interested in and what I am interested in is the difference between the universal and the esoteric, I suspect. I guess I have never … I do not think in those terms, but in some way, you know it takes an incredible ego to think that what it is that you are offering can be universally spread to every single person. I mean, obviously, you know … I guess you are with Corbusier and Mies then. I am much humbler. [Laughter.] I am just somebody who has my own personal obsessions. I obsess over something and I do not really care if nobody has any interest in it at all.

AP: Now, come on. Do not bullshit too much. You do not really care that nobody cares about what you do? Come on.

MC: That is a curious paralogism, which is ubiquitous in our conversations. The idea that in order to be political today one has to look back at a certain period of architectural history. That is nonsense.

AP: No, that is not what I am suggesting. I am suggesting that actually, Gilles' answer is back to some of the illusion of modernity, which believes that it could be an elegant engineering of the planet. And it failed. So, I think we have got to find a compromise. You are right in some ways. It is true that star architecture doing opera houses, museums and *Prada* shops when they want to be popular is not exactly the definition of a socially orientated architecture. But on the other hand, you know Hannes Meyer and others lead to a dead end. So, where are we?

MC: Well, not so long ago, as the late 70s in our schools of architecture, everyone wanted to design schools, hospitals and social housing.

AP: At the Bartlett?

MC: No, when I was a student.

AP: Okay, yeah, same for me. You know for us, it was even in a communist-ruled school. So, we were not allowed to do a tiny theatre before year three. Your one and two was social housing upon social housing. I remember the first time I had a little theatre to do. Wow.

MC: First schools to educate, but ...

RvT: First, I would like to make a note: I think we need to be careful about saying that the modern project totally failed. Because if we look to the 70s or if we look at the Second World War, what was the state of the world after the Second World War, but also after worldwide West colonialism and what the kind of standardisation provided, and have that introduced on a large scale, the dwelling right, for instance.

AP: Agreed.

RvT: Of course, we always talk that architecture failed and architecture believed that we could make a new society. Of course, they were part of a new economy, a system of control, but if you look statistically at the rise in health *et cetera*, we cannot just say that the project failed. I think that is a little bit what the left is now somehow disenchanted by and also worried by and stops them from thinking of alternatives and to have a project again to think of alternatives what we could then do next. So, I think we have to be very critical of the one project, but I think what it could mean to be modern is not a question we should stop, sure. But we should again take on board and experiment with alternatives even if we make mistakes.

AP: I agree.

RvT: And what I also read, and that is a good remark, that Le Corbusier was not designing cars as houses, but, in fact, was trying to find a way to make architecture with dignity. I think that was a very relevant point. What I thought about politics – I think that there are all kinds of politics. I think architecture is not about what we vote in parliament. Architecture builds for all kinds of regimes in different styles or at the same time *et cetera* is also a politics. But I think as Jacques Rancière … what you referred to was also a politics within architectural knowledge, within the aesthetics themselves, or what Bruno Latour says – you establish relations and those relations are not always neutral. There are differences in power which are also not bad, but there are all kinds of constructions and value systems which are unconsciously in operation through aesthetics. And they create situations as you said and they frame life. That kind of politics that Jacques Rancière said should not be an idea of politics, which is about policing, which a lot of architecture is also doing, but should be a kind of politics where it is about the senses and where people and things that have no voice start to get a voice against the norm. So, in fact, I think to invite the foreign or the other or migrants. And the migrant is not only the person but perhaps also the migrant within us to start to relate. And that I would call an idea of the politics within aesthetics, and I think it would be relevant from my perspective to also see in all these new technological explorations, which I think are looked at very formally, what kind of politics they make in fact possible through their technology. Because it is the new, it is a new sense of development ideas and imagination so I find it a missed opportunity to not address the politics or the aesthetic effect for the people who inhabit, who pass the building, who go in the building *et cetera*. So, that was my remark. What do you think about that?

AP: I am in agreement, guess what.

JS: There is a question coming up as soon as we are finished.

MC: We would have moved to another topic so let's take the question.

Q: Thank you, one more question. Maybe the architect is the only profession which is prepared in this within these walls who is acting according to the wishes of the client. Private entity, legal entity, an officer working on behalf of society within the legal framework set by society plus traditions. The question is if we are looking for the people who would like to neglect this maybe ideological framework set by all these numbers of people ... Maybe like Michael Reynolds in his nice movie *Garbage Warrior* from 2007, he lost his licence in the USA because he was neglecting the

ideological rules, the legal framework, *et cetera*. Do you think that technology maybe would allow us to get out of this circle and maybe set the profession free of ideological input like musicians, artists and other professions can right now?

AP: No. The answer is simple – no. For various reasons. One is that architecture is not exactly ... If you want to be free – be a writer, a painter, whatever and be prepared by the way also to matter less on certain things. You know, architecture costs a lot of money. Because it costs a lot of money because it has legal issues (the right to build, where, etc.) it is about power, about money, etc. So, there is no way you can escape ideology. In addition, I do not think it would be a good thing to allow an architect to build whatever they want wherever they want with a total disregard for what the client may wish. I think it is a negotiation. An architect that leaves a legacy is an architect that is both able up to a certain point to be in sync with the ideology of its time and make a difference at the same time. But architecture plays on the margins. If you do not want to play on the margins of the capacity of self-expression it is better to become an artist in the traditional sense or become a writer, *et cetera*. Architecture is an art that plays on the margins between self-expression and the expression of constraints which are social, political, economic, *et cetera*. And that is what makes architecture. You know, Gilles mentioned also the fact that architecture should conform in some ways to the urban fabric. That is another constraint, *et cetera*. So, you have to accept it or otherwise, you are not an architect.

RS: I do not think it is just accepting it. I think that architecture is always at its best when it is rubbing up against those constraints. I think when it operates in a vacuum it actually tends to repeat. And it is the going up against a whole series of other constraints that makes architecture a whole lot richer. I do not think it would be a desire to remove the active design from the profession and from the situation with the client.

MC: And technology – since that was a part of the question – is an instrument. Instruments without intentions have no function. So, let's not mix and match instrumentality and intentionality. Instruments are tools. Our intentions are what we make with them. So that in the case of architecture, without tools architecture does not happen.

AP: And in addition, something we almost never speak of in schools, *et cetera*, is that architecture is a collective production. You know, most of the big shots actually, you have got a number of people. So, architecture is not produced in the void. It is not a single person. Architecture is actually a lot of people toiling, usually, and then there is a signature name. Architecture functions in a very … If you want really to be an individual author, it is better to become a historian and you have the problem of course that you are desperately trying to find a public but that is a different thing. But it is a relatively solitary endeavour. And you are perfectly, you can say whatever you want. Usually the problem is rather that not that many people care about what you say, but you are perfectly free to do a lot of things that you cannot do as a practicing architect.

MC: But there is another solution. To become again artisans. An artisan makes what he or she (historically mostly he) has in mind. You think of a chair, you make it.

AP: Oh, come on, if you are making a chair or whatever usually you have to conform to what the client wants, I do not buy this artisan freedom. Actually, one created architecture as a discipline to gain freedom from craftsmanship.

MC: No, but an artisan makes the chair themselves.

AP: You are romanticising.

MC: Wait. Whereas, if you are an architect you cannot make a skyscraper yourself because it is too big. So you need teams of workers to make it happen. The difference is that between a painter who makes a painting with his own hands and a composer who composes a symphony for 250 instruments. Since he cannot play 250 instruments at the same time you must write it down and someone has to play it. That is when the symphony happens. It is called notation.

AP: I know it is one of your obsessions, but I do think I agree on the notation, *et cetera*. I do not agree on the artisan. Because if you look historically, an artisan is severely constrained by custom.

Panel discussion. Antoine Picon, Mario Carpo, Roland Snooks. Photo: Martin Siplane.

MC: Yes, but they did not make blueprints.

AP: Yeah, but come on. It was even more standardising: in some ways I would argue exactly the reverse. That the renaissance standardisation of the order was a way to allow for invention which you also wrote at some wiser moment of your career. [Laughter.]

MC: You were immature of my habilitation, so …

AP: Well, come on, you wrote an entire book on licence.

MC: Nobody knows that.

AP: Yeah, well, I do.

AC: We went into another topic that kind of does not fit anymore, but I would not say that the artisan is completely alone either, because the artisan is also part of a culture and a tradition and there is a knowledge, which is shared. And so in a way, you are never really completely alone and in that sense, I think that it is absolutely impossible that the architect can be completely detached from society. So in answer to the previous question, it would be like imagining that there is an entity completely outside of social context, which actually is not possible or it would make no sense. And then going back to the political question, perhaps it is that it is a matter of terminology or meaning because it is not always that what we mean by political, meaning that you take a party or you are aligned with a certain political ideology only, but as mentioned earlier, being political also means being in a certain position, in a context, so in that sense, having access or no access or being concerned about the environment is rarely a political act and in that sense it is not that much to do with the right or left, that would be a little bit of a simplification, really. Or even, we have also been discussing earlier about data, Laura

Corrigan, for instance, or Eric Stalder, are actually arguing that data is never mutual either, that data is always collected with a particular device, with a particular purpose, and is actually repurposed with a kind of goal and as a process with a particular goal. So, in that sense data also falls into this kind of social-political category – there is nothing completely mutual in that sense. So, I think taking a position is just necessary, it is not an enemy, going back to that question, it is where it is, right?

AP: Any historian could have told you that there is no such thing as a role data. Because data is always preformatted. In one way or another.

AP: I just wanted to kind of intervene in the discussion between you two just a few minutes ago when you mentioned the role of the artisan and the potential for the architect to develop into some sort of profession that is also able to actually manufacture somehow. True of course, like automation robotics and reimagining, that connection. And I just wanted to say, that actually there are, I recently noticed, there have been quite a few practices that have been working in that direction. I mean, I would say that Roland is somehow also a part of this, in our new kind of fabrication and you are so deep into, like, developing the actual technology and possibly building parts of it in the factories, in the labs at university and so on. I know people that have been kind of bind robots, that transfer them on site and build parts. In order to lower costs, generally, it has happened quite a lot, I have seen it around, so I would argue that actually, it is already happening somehow.

RS: But I think there is an important difference there between whether it is in aided design or if it is about fabrication. I am trying to get out of the fabrication business. I was really late too, I mean I come from a background of algorithmic work and so I saw a lot of my colleagues go into robotics and I was just very resistant for a long time, because I thought that this is not the problem for architects, until I got too frustrated about not being able to build and then decided I would give in and I would figure out ways of building. But, I think the problem is, every tool, whether it is a digital tool or pen or robot, dramatically affects what it is that you can design and there are people, I have thought about this a lot – do I set up a factory and become a builder, do I set up a factory full of robots and start building my own projects, but then, of course, you realise that even though a robot is an incredibly versatile tool in the way that, you know, laptops are pretty versatile tools, it still is going to dictate what it is that you design. And I guess I have realised that the real benefit of having a hands-on tool is that you can develop ways of making and designing simultaneously in a way that has feedback and I think that is where work gets tremendously interesting. But if you become the construction company yourself, then you are just going to lock into a certain way of working and then you are just going to repeat that, so I think that it is incredibly dangerous then.

AP: By the way, historically, most of the people who have tried to do that, they go bankrupt. It does not work. Now I wanted to go back to the artisan, because I think that I am just fed up with, to be honest, the mythology of the artisan first of all, because the artisan is not about freedom, it is about receiving a model, it is about following a tradition and 99% of what an artisan does is that, and you can actually trace both the birth of the modern architect and the modern engineer as trying to free invention from craftsmanship. So I am always surprised and by the way, when speaking of the gothic, we now know that the gothic was not this free spirit of everybody doing his little arch, *et cetera*, that it was super hierarchical, that the cathedral was actually a business enterprise, because the biggest question was not actually flying buttresses, but money, *et cetera*. And you had a hierarchy *et cetera*, so I think in some ways, let us not forget that the modern world and modern technology did free us, so the Ruskinian craftsman only existed in Ruskin's head.

MC: We are missing the point. That point is that designers need an act of design to convey their ideas to someone else who will make those ideas convert into reality, but as the artisan does not use blueprints, nobody claims what the artisan can invent outside society, we know how artisans were trained and how they were constrained just like anyone else, but the significant difference is that the artisan is not a designer in the sense that it does not use notation to tell other people how to materialise his ideas. This is the difference between the artisan, who does not

design and the designer, who does not build. And the position you were arguing (relating to Roland Snooks), is that of the designer, who goes back to using his own tools and so the separation between design and making is indeed being reduced by digitality, or rather it was 15 years ago.

RS: There is that reduction, but I am in a situation where I still need notation because I want to build larger things and I do not want to build them myself. And so, even though you might take on some of the understanding of the artisan, you might start to understand the relationship between design and fabrication. So, you still need a way of communicating it to somebody else to construct it.

MC: Except you are communicating with the machine.

AP: I am wondering if you might not have misplaced the medium without even realising it because you have a kind of position between the authenticity of the gesture, which would not be dependent on notation and the drama of notation as a sort of estrangement from the authenticity of the relation to matter *et cetera*. Reminds me strangely of the Derrida's *Of Grammatology*, the grammar of speech versus writing, so in some ways you hate writing.

MC: No, it is an idea, not a point.

AP: Yeah, I know, I know.

GR: I want to throw a few more logs on the fire about the artisan. I mean, I would also argue that actually, if you use digital machines, especially if you do not do subtractive methods, but you actually do additive methods, it is not a very artisanal way of working, it just means merely organising using a machine to organise bits and pieces which has nothing to do with ... It is directly to do with, you do not have the blueprint, but it is directly your idea that gets translated to a series of instructions. It has nothing to do with the gestures. So, I think the term artisan is really difficult there because the term artisan implies a kind of gestural, crafty thing. And I also am immediately allergic to the "artisan", the term for me is not intellectual, it is very, very difficult and that connection, which is interesting back again to politics, so essentially this kind of story of digital craft which has been kind of lingering around in this circle also comes in a way from a certain moment in Silicon Valley, where people were thinking that actually true access to tools, which is counter-culture, a phenomenon, that basically tracks us to tools, enabled people to become autonomous and start their own company, so the whole idea of the FabLab is like – look, we do not need to change the structures of society – we just need to give people access to tools, we will give every city a little FabLab with a laser cutter, a drill, a 3D printer and then people who are very poor and badly educated, do not have a job, they go to the FabLab, they get access to tools and they magically start a company.

AP: And by the way, they lose their job because of everything.

GR: Which is a deeply libertarian American ideology.

AP: You could argue also that it is perfectly compatible with a neoliberal project.

GR: Yeah, I was just doing that. It is completely, deeply delibertarian.

AP: It is highly problematic, because, I have really been struck in digital fabrication by how little thought has been devoted to, very often, the worker. Actually, I was glad to finally have a carpenter (relating to a member of the audience). Something, as if buildings and this is where, by the way, we are a little bit still walking on the head, because if you look around the world, the world is still full of people who build buildings and so there is very little thought, because Ruskin has been, the paradox of the Ruskinianism of the digital is that it is an excuse not to think of the status of the worker.

MC: But in a vastly historical perspective, the worker we have in mind is a robot.

AP: No, I do not agree at all.

MC: Wait and see.

AP: No, no wait and see. I am ready to bet.

MC: And the robot, the term means – "robota", when the term was invented in 1922 or something – slave labour.

AP: What an infalling perspective.

MC: Labour means the opposite of wage labour; robots do not go on strike.

AP: What I believe is that, with artificial intelligence, the first robot will go on strike. I wrote that piece about freeing robots because I do think that, it makes me very nervous, because usually we conceive machines as a way to reconceive our status as humans. And it makes me very nervous that as an ideal we are having slave machines. As a coincidence, I think it is a good excuse usually to go on with enslaving a large swath of the population.

MC: Better to have machines as slaves than have humans as slaves.

AP: That is what entrepreneurs have been saying since the first industrial revolution and that was a powerful incentive toward creating the proletarian class.

MC: Well, you know how Frederick Taylor, the guy who invented Taylorism in 1911, how he defined the worker at the moving assembly line, he called it an automaton. A gorilla with the intelligence of an ox. This is the human worker, which we are trying not to perpetuate.

GR: I actually disagree here, I mean, the slave worker, the whole point is that we do not, that we automate our labour, that is what humanity is striving to do. You automate your labour so that you ... (gets interrupted). The only problem is the political system, where it is embedded.

AP: Let us be futuristic for once, if you imagine that machines will become intelligent, I think one of the biggest problems we are going to have in the decades to come, that we are beginning to see with autonomous cars, or even if we are not going to see that many of them by the end, is the problem of the rights of semi-intelligent machines, are they higher than a cat, lower than the cat? Today, if you kill a cat with cruelty in France, you go to jail, and it is a recent evolution by the way, so does it mean that 30 years from now, and you see that now in science fiction movies, if you behave really badly towards a robot, a gentle robot, should you be punished or not punished? No, but I am the most futuristic in that respect, but I do believe that if we conceive of machines only as slaves as machines are becoming intelligent, we are going to run into trouble.

GR: Like, just to finish a point, without the first industrial revolution you would have no labour rights, no women's rights, no rights. And it is just like, to follow again good old Marx, you just accelerated to the point that production becomes so efficient that it does not require capital anymore, which is the digital. The whole point of the digital is that all is for free and the only problem is that we allow big monopolies to capitalise on free production and we cannot compete with them. But to organise Uber it does not actually cost a lot of money; it is almost free.

MC: Even independently of every political and ideological consideration, from a simple human vantage point, I do not see any reason why we should not abolish the work of minors in a coal mine. It is a shitty job. And if machines can do that, so much the better and there are so many, the workers on the moving assembly line were theorised as automatons with the intelligence of an ox. Nobody wants to do a bad job.
AP: Taylor was much more ambiguous because Taylor was actually a skilled politician and the scientific management of Taylorism was based on negotiation with workers that they would no longer work. So, he wrote that, but actually, Taylor himself worked on the shop floor and he knew very well that actually, for example, the workers did not give full productivity because they were not stupid, so the whole scientific management was a much more subtle enterprise.

RS: Some merits around mining. Australia is kind of a fairly …, we waste our opportunities in Australia and so our biggest industry is mining and miners are actually the highest-paid people per category in Australia. So, you would think that the greatest wealth in terms of salary is in the centre of the cities, but it is actually not. It is in these parts of Australia where nobody lives.

AP: Thank you, thank you ...

RS: But also, because we have such high labour costs in Australia, we are automating everything in mines. So now, we have these massive mines which produce incredible wealth and essentially nobody working there. It is all done by robots. So, now, all the wealth that was being transferred to these people who work these dirty jobs, who are overpaid in mines, if you really want money in Australia, become a mine truck driver, that is where all the money is, they no longer get the money because they are all robots, all the trucks and so what has happened now, of course, is that it is actually foreign massive multinational companies who are extracting all the wealth so I am not sure that the automation of shitty jobs is necessarily better for the people.

GR: This is just a political question, because machines are good, they prevent people from dying in mines.

MC: Yes, nobody likes to die in the mines.

AP: Have you read "Carbon democracy" (asking an audience member), because Mitchell in this book argues that actually, the mines were instrumental in fostering social progress. For a very simple reason, because people could go on strike and if you look at the greats of social progress of the late 19th century, people on strike. Robots do not strike; the problem then is that you have the unbridled domination of capital and that is it. It is a real issue.

DR: It is an absolutely fascinating discussion that you have about the specialisation of work and using robots for the automisation of different work fields that you apparently foresee. I would also really like those comments about AI, saying that if you equip a machine with an intelligence, at some moment you obviously have to give them as an animated entity some rights in order to participate and I think you are both right, just from my personal viewpoint.

AP (relating to Carpo): I hate to be right with him.

DR: You are both right and you are both wrong in the sense of the robot as a sort of specialised entity. So, we have taken everything, we have taken design, through computational design, we have taken digital fabrication and a sort of socialised fabrication for a larger entity, made that available to the masses with the FabLab, that was the conversation. We have been talking about automated construction through robotics, which supposedly is going to help the building industry and we have begun to talk about collaborative robotics in a sense that we actually do have a machine, rather less intelligent or not, a counterpart that supports work in a sort of larger field and actually what we are looking at is not specialised work but these robots, they have found implementation in the larger sense and in the largest scenarios, so if most architectural schools or an increasing number or architecture schools, maybe I should present it like that, actually do have robots as design elements, experimentation elements, so that we are able to recreate materiality and work processes *et cetera*. Where I am driving with all of that is basically, we are talking about digital reality, so we are fundamentally talking about a reality that is based on algorithms and I cannot but struggle with the idea that, how Harari has put it out there, and some people might have read "Home Deus", where the human actually has become an algorithm or will become increasingly an algorithm in itself, so in a way, what we are fighting for here is a distinction between us and them, between the machines and the humans, but I think we are actually much closer to a hybridisation of our intellectual capacities with these machines that we are creating and the way that they are intellectually and humanistically impacting our very being in the way that we understand ourselves as humans. So, we are not so far, that it is not going to be us and them, it is not going to be. We are already so much more technologised than we were not so long ago.

AP: This is exactly why I still want humans in a lot of jobs; I think we need a new equilibrium, that is what I believe, because actually yes, there will be, we are going to be facing machines which may not be intelligent in the sense we mean it, but which make decisions in our society.

DR: Are we calculating ourselves out of the equation is one question and my second question would be what do you see for 2050? What is going to be our reality?

AP: Of the same, but worse. Let us be optimistic. I think honestly that robots are not the biggest problem facing mankind. Honestly first of all because we are nine billion, so whatever we do, there will still be an entire swath of continents with cheap labour or a number of things, because there again we talk about robotisation, but China is full of Delorean workers. So, let's not forget the reality *et cetera*. So, I think the sad truth is that humans are very often cheaper than machines. If one day humans were really more expensive than machines, we would have made tremendous progress, but I do not think we are there. So, I am probably, the big difference with Mario is that we probably have a tendency to see the glass half-full or half-empty or whatever. I am very sceptical, for example, about a Rifkin kind of prediction. Honestly, I am extremely sceptical about that because if you look at the state of the world, you have rather rising inequality, a lot of people speaking about shitty jobs, shitty jobs are still multiplying around the world *et cetera*. So, I am not overly optimistic to be honest, I am reasonably optimistic that if by 2050 we had really begun to realise the extent of the problem, that we would be really great. That would be my take. If in 2050 you no longer have climate negationist, if the fact that inequality, you know, but let us be reasonable, I think two degrees Celsius by the end of the century, we are not going to make it. So, it is going to be tough. If by 2050 social inequality was finally seen as what it is that is, to say actually an obstacle to progress instead of believing that it is actually, in a Darwinian way, the best takeover of the poor, the less talented, I think we would have made progress. If architects by 2050 had realised a number of basic things also about their discipline I think I would be happy too.

MC (to Roland Snooks): Your turn to answer.

AP (relating to Snooks): You have one great advantage on us or disadvantage – you will still be there in 2050, which is more dubious for us. We were hoping, but ... you know, chances are so-so.

MC: In the long term, we are all dead.

AP: Well, in 2050, you and I, if we are still there, we will be very, very old.

RS (relating to Carpo): I am going to pass; I am going to leave it to you.

MC: Me too.

JS: It has been predicted that hybrids between computers and humans, as we know, will exist in eight years according to Ray Kurzweil.

AP (doubtfully): The singularity was supposed to happen in the early, you know, he has been moving up the singularity, so …

JS: No, no, he has brought it down, he said 2030, now it is 2028 and unfortunately the guy has a track record of something like 80–90% accuracy in technology. That makes me a pessimist.

AP: Oh, I do not believe Kurzweil at all, I think Kurzweil was invented, thank God, to prove that social sciences are still useful, because I have never seen such a heap of absurdities, so I think frankly the singularity …

JS: Why do you not look at market capitalisation …

AP: Yeah, that I am ready to believe, but you know, us uploading ourselves in machines *et cetera* is completely underestimated and we are underestimating a lot of things. And by the way, the singularity a few years ago was actually in the early 2020s and he moved it up and now he might be moving it down again, but the truth is, the "Singularity is near" as one of the craziest books I have ever seen.

RS: So, I mean, in terms of Kurtzweil and I am trying to bring this back to a question I have been dying to ask Mario and that is something about … So, what Kurzweil is interested in, I mean what he is trying to do is extrapolate through a particular exponential curve to talk about the way that ... That exponential curve cannot reach an asymptote, it is impossible to …

AP: Why?

RS: Well, about production, it is simply because of production, because production cannot be increased to an infinite point, so in terms of economic growth ...

Panel discussion. Photo: Martin Siplane.

AP: Oh, you mean a vertical asymptote.

RS: Yes, exactly. It never happens, so what it is, it is a conceptual problem, but what he is doing is that he is extrapolating out of surface information, out of big data, effectively. To use another term. So I guess my question for Mario is around this function-to-list question, which is sort of like the question of like model to big data and I think the problem with Kurzweil is that he is not interested in the underlying model of the world, he is interested in extrapolating data and you are relating calculus to the function, but of course all of the lists you are talking about, are generated through functions, like the material in the list is created through functions, typically through algorithmic functions, so I guess I get very worried when people talk about big data, when people talk about, you know, the way they talk about a list, because I see it as a total rejection of trying to understand reality. And architects do not need to understand reality, because we just make things, we do not need to understand what is actually there. I said it slightly tongue in cheek, but the thing is, what we do need to do is, we need to understand what is the model that we use to create those things. So, I think if we completely reject the function and embrace the list, then I think we are going to have the same problems that Kurzweil has.
AP: You know, when I was young, I studied mathematics and in mathematics you would take an unusual amount of time to do things which had no practical impact, which was to demonstrate that a differential equation had a local solution. We did not provide you any idea really about how the solution looked but enabled you to understand in-depth the structure of the differential equation. This is almost gone in engineering school, because actually you use a machine to just calculate the solution to the differential equation, so it is probably, I think the way I understood, that it is probably substituting a structural understanding of mathematical problems. I think your example of the function is wrong by the way (relating to Snooks), but it is true that there is a shift from understanding to computing. And that is a fundamental problem for humans so far, except

if actually what we believe we understood was just computing, which is another possibility.

JS: Let us make a proposal. It goes to the dean up there. Let us meet in eight years, here, the same people, the same keynotes and look at the world, Space and Digital Reality 2.0 let us say.

AP: Can we make it in four years?

JS: We do not know whether Ray Kurzweil has been uploaded yet, but 2028 …, of course, we can come before that. So please, dean, have it in mind that in eight years, on 11 September we are going to have a conference to discuss this again. But before that, there is a comment.

MC: We should come in scuba diving gear, because you would be underwater, right.

JS: We will see.

Q: We were discussing this issue with craftsmen and handicraft and when will everything be digitalised and I think a nice summing up position is that we do not have to think about this moment when machines will take over, but I think it was 12 years ago, when this Second Life internet platform came up and everybody was a little bit afraid that nobody would leave their house anymore, because everything will happen in Second Life, but to be honest, if we just, we just have to take away all batteries from a building site and then we will see how connected we are already, so the excavator will not work anymore, because the guy who handles the excavator is already a robot in some kind of way, of course, I do not know how far we are, but some plans are already on the iPad and of course the excavator itself is a robot for the person himself, so I do not think that we have to search that far in the future, when everything will be digitised, just take away my mobile phone and I will not be able to return to my hotel today, so I think that we do not have to look so far in the future, but …

JS: We will drive you.

Q: But not with Uber I think or my credit card, so I think we can already look in the current moment and think about what hybrids we are already developing, linking the carpenter and the architect and the craftsman.

MC: Can I add a note on an unrelated topic. Based on today's presentation, the number of quotations, the topic, which was top of the list of citations, was not politics, it was not technology, it was timber. By number of quotations, timber is top of the list. Does it mean something? Timber in very different connotations. Your timber is different from his timber (relating to previous audience members, who joined the discussion), but it was still timber.

AP: They believed they were doing 'function' and they were doing 'list'.

JS: It looks like we have come to the end of the panel unless there is one more question and there is. But this will be the last question for this year's conference. Q: I have a question. For me, there is a lot of talk about technology and I am a master student here and like most students, we work through references, so if I can consider you guys somewhat visionaries in your field of work, what are the references you use and do you think there is also, especially I think one topic which was not really mentioned today – social media. Do you think that for example we are influenced by references in today's world also and will that also become part of technology which also affects us in the future?

MC: I do not use social media, so I cannot answer.

AP: I think social media is part today of this kind of extended self, you manage it with shift, for example, the shift from *Facebook* to *Instagram et cetera*. It is quite striking how *Facebook* has become a kind of older generation thing, but it is clear that it is part of the thing, actually I did not mention it today, but I very often mention it because I think it is fundamental. Where I am a bit also sceptical about Kurzweil is, their scheme goes with the idea that we would be reasonable by the time of the singularity. I think social networks have demonstrated that actually with all these magnificent tools we can be even more stupid than we were without them, so there is hope for the worst.

JS: Thank you. With that optimistic note, we should conclude this panel. Thank you very much!

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Graphic design: Martin Rästa
Printed by: Ecoprint AS

The conference was supported by Cultural
Endowment of Estonia.

This publication has been supported by Cultural
Endowment of Estonia, Republic of Estonia
Ministry of Culture

ISSN 1736-4477
ISBN 978-9949-594-95-5 (print)
ISBN 978-9949-594-96-2 (pdf)

EESTI KULTUURKAPITAL

KULTUURIMINISTEERIUM

EKA Estonian Academy of Arts

ISBN 978-9949-594-95-5