Proceedings of the International Conference on

GSM4Q

game set and match IV 2019 qatar
connecting people spaces machines

Editors
Ahmad Mohammad Ahmad
Fodil Fadli
Kas Oosterhuis

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Acknowledgement

Introduction

Author: LPI Professor Kas Oosterhuis, researcher Qatar University, Emeritus Professor TU Delft and professor Qatar University [2017-2019]

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GSM4Q Conference Theme

The GSM4Q conference proposal addresses new Philosophies, Strategy and Directions towards 3D Creative Thinking Skills for the Digital Construction Industry, aimed at the general public and framed as "Connecting People, Spaces and Machines".

New Directions in Architectural Design and the Building Industry

The world is changing and it is changing fast. Like other countries, Qatar must find its own unique ways of coping with rapid changes. The 4ᵗʰ Industrial Revolution has already left its mark on societies and is breeding many startup companies. The 3ʳᵈ Industrial Revolution was the digital revolution that brought us computers, cell phones and the Internet. The 4ᵗʰ Industrial Revolution is the revolution of connectivity between things and people, referred to as the Internet of Things and People (IoT&P). People and devices/machines will find a new way to communicate and work together in the new ecology of things and people. We will see automated vehicles on the road, smart homes and workplaces, customization in all niches of the industry, individual preferences customizing one's immediate environment on the fly. All this will inevitably affect the local practice of Architecture and the education in Qatar-based universities. The question is "how do we as practitioners, researchers and educators effectively and proactively respond to the inevitable changes that the 4ᵗʰ Industrial Revolution will bring about?"

Working inside the Internet of Things and People

The keyword is connectivity. A people-to-people connectivity, between people and machines, and machine-to-machine connectivity. Machine to machine communication is based on the transfer of data, controlled lean data and big data alike. Big data are evaluated through sets of connected algorithms as to analyze and optimize people flows, data flows, climate control, traffic control etc. Lean data transfer methods are used for the immediate machine-to-machine communication that drives robotic building techniques, ranging from design to production processes and robotic 3D printing technologies to human-machine interaction, and living and working with robots. Qatar needs to prepare its economy for the future, and identify through state-of-the-art research, innovation and education the proper methods and tools to cope with the rapid change that lies ahead of us.

Digital Connections

All connections inside the IoT&P unfold via digital data transfer and hence knowledge transfer. Tools and methods thriving in the 4ᵗʰ Industrial Revolution are per definition data driven, meaning that architectural and engineering design methods must become data driven as well. If not catching up with the reality of the current developments in society, the now emerging dynamic connectivity between the disciplines will be lost and one will fall back to traditional methods of communication between the disciplines, with all dangers of misconceptions and misunderstandings, risking a disconnect from the places where the important societal

and economic decisions are made. The essence of the 4ᵗʰ Industrial Revolution, which is the connectivity between things and people, means inevitably a cross-disciplinary approach.

GSM4Q offered an important vehicle to disseminate the current most innovative developments in the field of architectural engineering.

The participants of the conference, both practitioners and students were exposed to, and appreciated the opportunity to discuss with experts from different research disciplines and with experienced practitioners of advanced building methods. The general aim of the conference has been to become acquainted with the 'digital' in the most natural way. Professionals build upon the natural new creative abilities of high school and university students. The professionals have been extremely successful in stimulating the students and graduates from Architecture and Engineering to work creatively with the new tools and virtual realities, thus taking advantage of the natural interests of the new generation.

GSM4Q aimed to inform and stimulate the Qatar-based construction industries and their experts to adopt the new robotic methods of design, manufacturing and building. For the Qatar industries, it meant a further shift of focus towards the digital and towards 3D and 4D thinking, designing and manufacturing, as to promote new industries and encourage further economic diversification.

Connecting People, Spaces and Machines

The theme of the Game Set and Match IV Qatar [GSM4Q] conference was "Connecting People, Spaces and Machines", with the subtheme 'The Informed Nomadic Monad'. The GSM4Q conference covered a variety of specific yet strongly connected topics like Nomadic Swarms, Nomadic Cities, Robotic Buildings, Informed Materials, Monads and Nomads, Scalable Interactions. These and other topics were targeted by the keynote speeches, and challenged by the hands-on workshops and the call for papers.

GSM4Q topics were structured along the lines of the scalability of the connections between constituting Monadic components. Leading themes for the conference sessions were-1. Informed Nomadic Swarms, 2. Nomadic Cities and Buildings, 3. Monads and Nomads, and 4. Scalable Interaction.

Day One was dedicated to the notion of the Nomad; Day Two was for dealing with the notion of the Monad. The 2-day conference was framed in four discrete sessions, Day One morning session was structured around the theme of the Universe, Day One afternoon session dealt with the theme of the Community, Day Two morning session addressed the theme of the Body, while the Day Two afternoon closing session covered the theme of the Cell.

Inclusive Approach with Respect to Tradition and Modernity

The adoption of new digital techniques does not necessarily mean a departure from traditional styles and customs. In fact, the new digital and parametric design techniques are inclusive by nature, just as well applicable to traditional design styles as to modernism and the next generation buildings. For example, 3D printing techniques are perfectly fit for making elaborate 3D Islamic patterns for shading structures in facades and even for more complex load bearing decorative structures. Yet, the 3D printing techniques may just as well be used for the structural optimization of larger multi-story buildings and hence lead to a complete new expressive quality in architecture, not traditional, not modernist, but representing the natural form of the next generation building.

Goals and Objectives as enshrined in QNRS 2012

GSM4Q has addressed the following Goals and Objectives as described in the Qatar National Research Strategy (QNRS) 2012. In particular the GSM4 conference addresses, under the Computer Science and

Information Technology Pillar (ICT), the following specified goals:

ICT 4- Systems, applications and robotics: Develop technology applications and services that support existing industries, promote new industries, and encourage economic diversification.

GSM4Q addressed state-of-the-art robotic building systems and new technology applications for the construction industry.

ICT 4.1- Develop a research and development program on wireless networking to develop and employ an integrated, next generation, wireless sensor network, including research on mobile applications and services.

GSM4Q addressed the Internet of Things and People through interactive architecture, and looks forward to the Next Generation Building, which builds the general theme of GSM4.

ICT 4.2- Develop a research and development program on embedded and integrated systems and sensor networks as an enabler for development in many sectors.

Strongly related to and in parallel with GSM4Q, Prof. Kas Oosterhuis and Dr. Fodil Fadli of the Qatar University aimed at rethinking and redefining the curriculum of the Department of Architecture and Urban Design. Furthermore, in the Outreach Program of the Department of Architecture and Urban Planning, they have enhanced ties with the Qatar-based construction industry and the cultural community of Qatar in general as to identify practical implementations of the presented philosophies and strategies.

ICT 4.3- Build a research and development program on applied robotics with use-inspired applications to include work on computer vision and the integration of state-of-the-art robotics systems.

Robotic building strategies have had a central place in GSM4Q. Special attention has been given to the connectivity between advanced parametric design and data driven manufacturing methods, robotics and user-inspired applications.

A call for papers has been addressed to the key players in the field, experts and PhD candidates worldwide.

GSM4Q Initiative

Mostly, GSM4Q was started based on Prof. Oosterhuis's large network of leading international architects and researchers, and he programmed the content as the sequel of his previous GSM conferences at the TU Delft [2002, 2006 and 2016], where he was professor in practice and held the Digital Architecture Chair. The content was developed as to give the architectural community in Qatar, students and faculty of Qatar University a deep insight of the state-of-the-art development in the international architectural arena of today, enriched with presentations of recent iconic projects under development in Doha.

GSM4Q Team

The GSM4Q team members-directed by Prof. Oosterhuis as LP, consisted of the Head of Department of Architecture and Urban Planning Dr. Fodil Fadli, Assistant Professor Dr. Ahmad Ahmad, Research Assistant Sara Zeina, both faculty members from the Department of Architecture and Urban Planning, strengthened with Qatar-based Dutch-Hungarian Visual Artist Ilona Lénárd, Architect Yassmin Alkhasawneh, at times assisted by independent Project Manager and former Dutch ambassador Winand Staring and researcher Dr. Pablo Baquero.

Tasks were distributed among the team members, while Prof. Oosterhuis as LPI was responsible for the general management, the conference content, the general vision, inviting international and national

speakers, and the financial management, whereas Fodil Fadli took care of department related procedure; Ahmad Ahmad and Pablo Baquero organized the call for papers, Sara Zeina took care of designing and managing the website and securing the hospitality, with Ilona Lénárd assisting the general management, and Yassmin Alkhasawneh helped with publicity, designing the posters, flyers and brochures. It was considered important from the beginning and has been proven successful to have QU staff working together with non-QU experts as to broaden the general scope and vision of the GSM4Q conference.

GSM4Q Budget

Initially, in our proposal we requested 50,000 USD, and got 25,000 USD from the QNRF, largely due to the fact that the publication of the proceedings could not be financed from the QNRF budget. Hence, we arranged with Qatar University Press to take care of the publication of the proceedings, which resulted in the book that is in your hands right now. Based on the reduced budget we had to focus on the maximum impact by inviting distinguished speakers, offering them non-refundable tickets, a stay in an upmarket five-star hotel-the Hyatt Regency Doha, but we could not afford to pay them daily costs. Fortunately, almost all speakers agreed, except for the celebrities Rem Koolhaas and Jean Nouvel, they both cancelled at the last moment due to other urgent businesses.

GSM4Q Program

The thematic structure and the invited speakers for the initial program was largely maintained up to the final version. There were mainly some changes with respect to the keynote speakers. The world famous natural physicist, Prof. Erik Verlinde could not be reached, yet we found the astrophysicist, Prof. Vincent Icke, equally well known in The Netherlands as scientific author and from television appearances, an excellent replacement. The Architect of the Qatar National Library Rem Koolhaas was not able to attend, but we found an excellent replacement for him too, by having Mrs. Fatima Fawzy to talk on the development and achievements of the Msheireb and Hani Hawamdeh of Ibrahim Jaidah AEB office to talk on the Thumama stadium. After all, the intention was to have talks on realized iconic buildings in Doha during the Monad/Body/Building sessions. Also, Jean Nouvel was not able to come, but we could replace him by Hafid Rakem, the Director of the Ateliers Jean Nouvel in Doha, giving the audience interesting insights into the development of the design of National Museum of Qatar. We had 12 renowned international speakers and 5 distinguished local speakers on stage.

Call for Papers

We decided at an early stage to open the Call for Papers, and the LPI personally invited 27 respected colleague professors and researchers to serve on the Scientific Committee and review papers [attachment 4, list of Scientific Committee members]. We received 33 submissions from a variety of researchers, professors, PhD candidates and practicing architects, and we had 10 paper presentations during the GSM4Q conference in the VR Lab at the Library Building [room 111], opposite the Auditorium [room 117]. The review of the papers was done via the Easychair System, whereas the papers were assigned to the members of the scientific committee, while the GSM4Q team reviewed the opinionated essays.

Easychair

We subscribed to the Easychair Conference Support System, which could be obtained free for half a year. The last reviewed and adjusted papers came in the final week before the conference. We received 33 interesting papers mainly from Europe, with an overall high standard, and on topics that were well related to the themes of the conference. It will form a great book and an asset for the DAUP students.

Day One | The Nomad

Day One started with talks in the opening session by QNRF, DAUP and me. The President of Qatar University Dr. Hassan Al Derham, the Dean of the College of Engineering Prof. Abdelmagid Hamouda and Vice Dean of Research Dr. Abbes Amira attended it on personal invitation from the LPI.

The morning session labelled "Universe/Planet" started with an excellent educational presentation by Prof. Antonino Saggio, titled "Crossing the Rubicon". This was followed by a very special presentation by Prof. Vincent Icke, the astrophysicist. Especially the students embraced his professional and knowledgeable presentation; they had not heard such deep insights before. The same is true for the following presentations by Prof. Marcos Novak, the renowned Trans-Architecture Pioneer, Dr. Nimish Biloria on Smart Cities, Rezone on the Little Babylon project and the participatory development of Minitopia; not to forget, the extremely sweet and intriguing presentation by Liudmila and Vladislav Kirpichev from Moscow on their School of Architecture for children aged 2-16 years, Qatari Architect and Project Manager Mrs. Ameena Ahmadi and Prof. Oosterhuis secured in-depth forum moderations. Day One was considered a huge success.

Day Two | The Monad

At Day Two, we focused more on the realized state-of-the-art buildings in Doha and elsewhere, with presentations by Dr. Fodil Fadli of the DAUP, Prof. Ali Raouf of the Ministry of Municipality and Environment, Ali Mangera the Architect of the Center for Islamic Studies, Hani Hawamdeh of Ibrahim Jaidah's office on the Thumama stadium, and a presentation by myself on his recent projects in Netherlands and at Qatar University, and a variety of Outreach activities at Fire Station and entering Qatar competitions. I showed among others, the Robotic Workshop at Fire Station titled "Machining Emotion", a successful and imaginative collaboration between Qatar University/Ceng, the 2018 DAUP Students Design Course, Visual Artist Ilona Lénárd and Doha-based Architect Yassmin Alkhasawneh. We programmed robotic vacuum cleaner to make large additive [painting on 10m long canvas] and subtractive [sucking up flour particles away from the floor and this leaving traces].

The afternoon session was dedicated to 3D printing and other state-of-the-art robotic designs and manufacturing techniques, with presentations by Asst. Prof. Philippe Morel of XTree company, Prof. Philippe Block from ETH Zurich, Shajay Bhooshan of the Code Department of Zaha Hadid Architects, closing with a disarming presentation by Hafid Rakem of Jean Nouvel Studio in Doha on the National Museum for Qatar. The moderation was perfectly done by Yassmin Alkhasawneh that led the speakers into a very lively final discussion on the relation between the global problems of limited resources and modern robotic design and manufacturing techniques.

The lectures were recorded using cameras on tripods and cell phones by students and the GSM4Q team. The recording will be posted on YouTube and Vimeo as to leave a permanent trace on the Internet. In addition, we broadcasted some parts using live streaming on Facebook.

The Venue | QU Library Building Auditorium | VR Lab

Booking the Auditorium was a challenge, while there were not many timeslots left to reserve for GSM4Q. We found one good day and negotiated with a student organization that had already reserved part of the other day; we reached an agreement that we could use the Auditorium for two full days. The Auditorium was therefore important for us, while we wanted it to connect to the VR Lab, where the paper presentations took place on one side and the public could navigate through some complex VR models on the other screen in the breaks between the lectures.

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February 6-7, 2019   Doha, Qatar

GSM4Q attended by students, faculty, professionals and speakers.

Attendance

The GSM4Q conference was well attended, mostly according to expectations. Besides the more than 20 active participating speakers, we welcomed an audience of some 60-80 people, many of whom stayed for full days. We had almost all of my colleague professors attending large parts of the conference and they were without exception very positive. Especially the attendance of our female DAUP students was excellent, largely a bunch of active senior students and 3rd/4th students that I had before and now taught in my design courses. Also, I spotted some of my first year students, which is a good sign that the future generations show interest in the subject which the GSM4Q conference discussed. Besides speakers, staff and students, also the Industry was well represented with a dozen or more attendees during the 2 days of the conference. We did not register all of the visitors while we wanted the setting of the conference informal and relaxed. People had a very good time, without hesitation it was appreciated by all of the visitors as value for time.

Little Babylon Interactive Sculpture

To enhance the GSM4Q conference with a participatory workshop, we brought the Little Babylon project to Qatar University and inflated the interactive sculpture in front of the QU Library. Although well prepared with the proper forms, the driver experienced some 2-hour delay in being allowed to enter Qatar University, and finally tried to deliver the package at the Facilities Call Center. Unfortunately, it was not accepted to be delivered there, but we managed to have it transported to the DAUP C07 building. From there we brought it on the first working day, Sunday 3 February, to the location in front of the Library. That day was very bad weather and we had to postpone the setting up to Monday. Even on Monday, the winds were blowing too fast, but the Rezone team from The Netherlands was able to prepare everything for inflating the object on Tuesday. The workshop part was therewith reduced to the days of the conference itself with the participation of speakers and students. Thanks to the generous assistance of the Facilities Call Center, and especially Mr. Odai for setting up and breaking up Little Babylon inflatable as a remarkable event.

Hospitality

All speakers were welcomed at the 5-star Grand Hyatt hotel, for which the GSM4Q team managed to get a competitive price offer. The speakers appreciated the excellent level of hospitality that we offered them during the days of the conference.

Feedback

I personally knew most speakers from earlier conferences, some of them having become close friends, but many of them did not meet each other before. In terms of building relations, the GSM4Q conference was an immense success, not only for the speakers themselves, but certainly also for the many [female] students who attended the conference. In addition, my colleagues at the DAUP joined the conference and we received very positive feedback from them as well.

Students told us that they learned things about the state-of-the-art architecture and the engineering of architecture that they were not informed about before at the regular courses and design studios. It clearly shows the importance of having such strong content-rich international conferences at Qatar University on a more regular basis.

Closing Words

After the lively discussion as GSM4Q director, I shared a few closing words, by using the following one-liner [after a fierce exchange of opinionated positions by an optimist Philippe Morel and Philippe Block]:

"Thank you Philippe for making us feel bad, thank you Philippe for making us feel good, thank you all."

We took off-deeply satisfied after a meaningful conference-to have a group photo and headed for the speaker's dinner in Souq Waqif.

Group photo of national and international speakers in front of Little Babylon and the QU Library Building.

Guided Tours

Before and after the two GSM4Q conference days, we offered guided tours to the speakers on the 5th and 8th of February; Tuesday the 5th we organized a guided tour in the Qatar Foundation Headquarters, that was designed by OMA. This visit was very special and highly appreciated by those who could attend. After the QF HQ, we visited the Qatar National Library and the Center for Islamic Studies. Friday the 8th we had a tour with some other speakers to the art project East-West/West-East in the Zekreet desert. Afterwards we went to the FBQ Museum where both Ilona Lénárd and Yassmin Alkhasawneh [both external collaborators of GSM4Q] had an excellent show of their recent art works in the White Majlis. Then we also visited the QNL and the Center for Islamic Studies in the Education City.

Speakers/Organizers at East-West West-East sculpture by Richard Serra in Zekreet desert**.**

GSM5Q

For many, especially the students, GSM4Q conference was an eye-opener, a game changer, offering insights in new developments in the fields of digital architectural education, the architectural parametric practice and data driven robotic construction. The deep insights and experience they were offered by the international speakers will inspire the students for years to come.

We are planning to have the sequel GSM5Q within two years in 2021.

Kas Oosterhuis, Rotterdam - Budapest - Doha 2019

GSM4Q QU Webpage

QATAR UNIVERSITY ORGANIZES GSM4Q CONFERENCE ON ARCHITECTURE & URBAN DESIGN

11-02-2019

Qatar University (QU) College of Engineering (CENG) Department of Architecture and Urban Planning (DAUP) organize the GSM4Q conference, which is the 4th in a series of Game Set and Match conferences on the state of mind in architecture and urban design. The conference is under the theme "Connecting People, Spaces and Machines: The Informed Nomadic Monad". The GSM4Q conference covers a variety of specific yet strongly connected topics like swarm behavior, distributed climates, robotic buildings, informed materials, monads, nomads, scalable interactions, smart environments.

The event was attended by QU President Dr. Hassan Al-Derham, CENG Dean Prof. Abdulmajid Hamouda, CENG Associate Dean for Research and Graduate Studies Prof. Abbes Amira, Head of DAUP Dr. Fodil Fadli, DAUP Prof. Kasper Oosterhuis, students, faculty members and other representatives from fellow higher education institutions in Qatar, as well as professionals and practitioners from governmental and private institutions.

In his opening speech, Dr. Fodil Fadli said, "This event is important to our department because it triggers interaction between faculty members, students and professionals with international speakers and scientists, who come from different backgrounds and different areas of expertise. We are here to discuss connecting people, spaces and machines in the realm of 21st century architecture. Our department is ready to explore and reach new horizons to empower next generation architecture students".

DAUP Professor Kasper Oosterhuis added, "The leading theme of the GSM4Q conference is "The Informed Nomadic Monad". The monad is considered to be a design pattern that defines how inputs, processes and outputs together build generic types, as in functional programming. The nomad links back to the Bedouin history of Qatar and forward to its potential for today's strategic planning".

The same text also appeared on the "Qatar is Booming" website.

Foreword by Qatar University President

Qatar University, with the support of Qatar National Research Funds (QNRF), welcomed academics, researchers, professionals, and students from around the world for the *4th Game Set and Match (GSM4) 2019 Qatar: Connecting People, Spaces and Machines - The Informed Nomadic Monad* conference hosted at our QU-Main Library on 6-7 February 2019. As a national university, we recognize our responsibility to uplift the culture and the identity of the Qatari society. Hosting *GSM-IV* was in keeping with and supportive of the State of Qatar's vision and the development strategies, under its Social Development Pillar, to "preserve Qatar's national heritage and enhance Arab and Islamic values and identity," specifically in developing a better future for architectural practice in the State of Qatar. This book of proceedings records achievement and posterity in the architectural design field. The intellectual conversations and fascinating debates held during the whole conference through a variety of specific yet strongly connected topics of interest about architecture, arts, urban planning, education, engineering, design, creativity and innovation.

Dr. Hassan Al-Derham
Qatar University President

Foreword by the Dean of Qatar University College of Engineering

These proceedings contain the papers presented at the 4th Game Set and Match (GSM) Conference held in Doha, Qatar, over two days in February 6-7th, 2019 at Qatar University campus. The Delft University of Technology in The Netherlands hosted the first GSM conference in 2006. Qatar University was pleased to continue this tradition of intellectual curiosity about architecture and form first began by the Department of Architecture and the Built Environment at Delft. The Department of Architecture and Urban Planning in the College of Engineering hosted the conference with sponsorship from the Qatar National Research Funds and the Qatar University-College of Engineering. Its purpose was to provide an international forum for discussion and exchange of the latest ideas and concepts about multifaceted notions of the hyperreal in the field of architecture. It is an endeavor worthy of the College of Engineering at Qatar University. I would like to thank Professor Abdelmagid Hammuda for his efforts to make the GSMV event a reality.

Dr. Khalid Kamal Naji
Dean of College of Engineering, Qatar University

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February 6-7, 2019   Doha, Qatar

Foreword by the Head of Department of Architecture & Urban Planning

The keynote speeches, submitted papers, and workshops of the 4ᵗʰ Game Set and Match (GSM) Conference.

GSMIV-Qatar 2019 international conference covered a broad range of topics over a condensed two days February 6-7ᵗʰ, 2019. This publication documents the scope and substances of those topics, such as Nomadic Swarms, Nomadic Cities, Agile Vernacular Cities, Robotic Buildings, Cybernetics, Informed Materials, Monads and Nomads, Biomimicry, and Scalable Interactions. It included several different approaches to the conference theme from the perspective of computer-aided design, virtual reality, design processes and methods, to design tool developments and novel design applications in architecture. The GSMIV conference highlights the role of the Department of Architecture and Urban Planning (DAUP) and College of Engineering at Qatar University in embedding and integrating the Qatar National Vision (QNV) 2030 and Qatar National Development Framework (QNDF 2032) in architectural education. These strategies are well embedded through the unique educational process, blending digital technologies to architectural identity, creative teaching and hands-on learning experiences. It also connects innovative research with local and international stakeholders to achieve the subtle goal of a resilient sustainable built environment for Qatar and the world in the 21st century and beyond.

Dr. Fodil Fadli, Architect, Ph.D
Department Head, Architecture and Urban Planning, College of Engineering

Sponsors

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Part I: Full Papers

Participator, A Participatory Urban Design Instrument

Kas Oosterhuis MSc[1], Arwin Hidding MSc[2]

[1]Qatar University / Director ONL

[2]Designer-programmer

oosterhuis@oosterhuis.nl

Abstract

A point cloud of reference points forms the programmable basis of a new method of urban and architectural modeling. Points in space from the smallest identifiable units that are informed to communicate with each other to form complex data structures. The data are visualized as spatial voxels [3d pixels] as to represent spaces and volumes that maintain their mutual relationships under varying circumstances. The subsequent steps in the development from point cloud to the multimodal urban strategy are driven by variable local and global parameters. Step by step new and more detailed actors are introduced in the serious design game. Values feeding the voxel units may be fixed, variables based on experience, or randomly generated. The target value may be fixed or kept open. Using lines or curves and groups of points from the original large along the X, Y and Z-axes organized crystalline set of points are selected to form the shape of actual working space. The concept of radical multimodality at the level of the smallest grain requires that at each stage in the design game individual units are addressed as to adopt a unique function during a unique amount of time. Each unit may be a home, a workplace, a workshop, a shop, a lounge area, a school, a garden or just an empty voxel anytime and anywhere in the selected working space. The concept of multimodality [MANIC, K Oosterhuis, 2018] is taken to its extreme as to stimulate the development of diversity over time and in its spatial arrangement. The programmable framework for urban multimodality acknowledges the rise and shine of the new international citizen, who travels the world, lives nowhere and everywhere, inhabits places and spaces for ultrashort, shorter or longer periods of time, lives her/his life as a new nomad [New Babylon, Constant Nieuwenhuys, 1958]. The new nomad lives on her/his own or in groups of like-minded people, effectuated by setting preferences and choices being made via the ubiquitous multimodality app, which organizes the unfolding of her / his life. In the serious design game nomadic life is facilitated by real time activation of a complex set of programmable monads. Playing and further developing the design journey was executed in 4 workshop sessions with different professional stakeholders, architects, engineers, entrepreneurs and project developers.

Keywords: Point cloud; Voxel working space; Anytime; Anywhere; Multimodality; Urban; Nomad; Programmable; Monad; Sliders; Random; Porosity; Stakeholders; Role play; Expert; Serious game; Design game
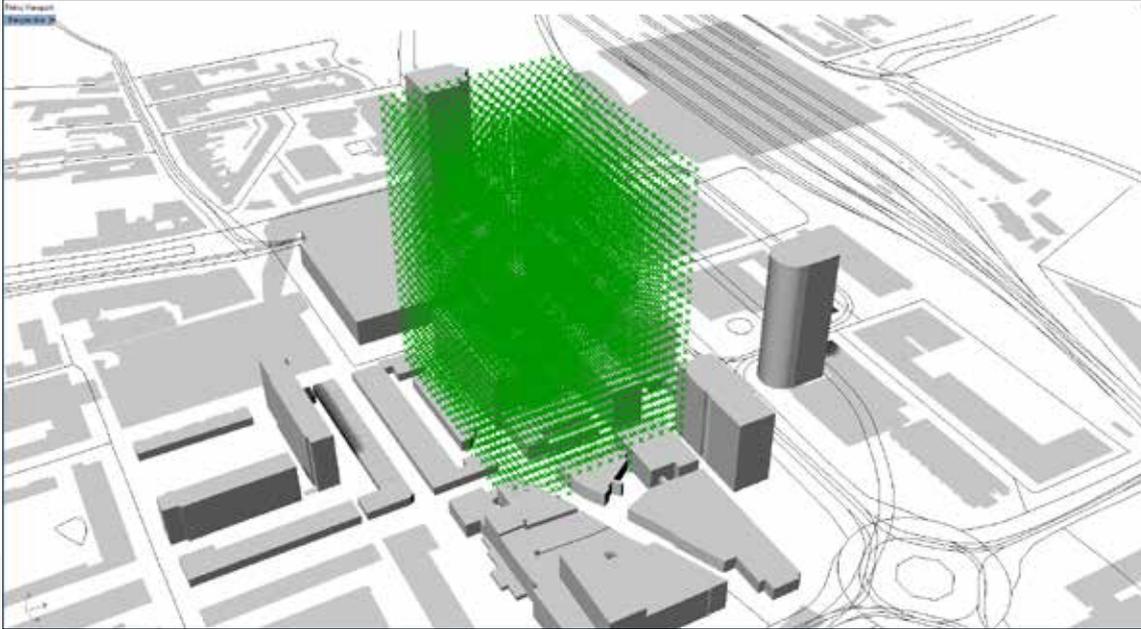
Figure 01: | ONL | Manhave urban design instrument | 2018 | initial point cloud.

Figure 02: | ONL | Manhave urban design instrument | 2018 | selected working space and random selection of reference points.

The Point Cloud

The point cloud of reference points is chosen such as to encompass the totality of an urban block in the center of Rotterdam, The Netherlands. The height is temporarily fixed as a practical demarcation of the initial working space, the design game unfolds within this pixelated space. When we would need more space for expanding ideas or exploring potential more in detail, the initial working space is simply enlarged or set to a higher resolution. The point cloud is intentionally designed to identify the smallest working unit, referred to as the voxel, while the design game is set up such that each individual voxel, groups of voxels and all voxels can be informed to have any value or property. The distance between the voxels is chosen to match the size of the volumetric voxels that are in subsequent steps labeled as functional units.

The Shape of the Working Space

Freehand sketched or controlled straight lines are introduced to make the selection of points of the initial point cloud. By setting values for the tunnel of influence along the lines the selection grows or shrinks. The selected points are represented by a cube of 7.2 x 7.2 x 7.2 m, to function as the programmable urban unit, fit to be programmed by their future users. The freehand sketch affected pixels of the initial working space are represented as functional voxels. The selection of pixels crystallizes as a series of connected voxels. The working space of selected voxels includes existing buildings as their repurpose and / or redesign may form part of the unfolding urban strategy. Due to the parametric nature of the system the design tool can be applied to different sites in a relatively short time. Selected pixels may be "baked" [from Grasshopper to Rhino] as a 3d model to form the basis for further modeling manipulations. In real time the effect of many different trajectories and thus the spatial outcome of different selection of voxels are explored in participatory workshop sessions with participating stakeholders, some of them experts in 3d modeling and design, others laymen with respect to modeling, being expert in other fields [financial, social engineering].

Porosity

To avoid the rigidity of the traditional close packing of predefined volumes, we have introduced the concept of porosity of the three-dimensional urban fabric as to stimulate 3d thinking and surprising spatial arrangements, thereby facilitating the diversity of needs and secret wishes of the nomadic international citizen [MIC]. Effectively porosity is represented using a randomizer to select the empty voxels. Selected voxels may seem to float in space when no voxel is selected under or besides the voxel that is assigned to a function. A porosity factor of 50% means that 50% of the selected reference points are visualized as cubes, in a random 3d configuration, the other 50% is left blank. Colors for specified voxels indicate the variety of functions, which are free to choose and to add: homes, gardens, workplaces, etc. In the urban instrument the voxels are assigned in a random 3d configuration, but in the further architectural design process these porosity voxels can be clustered together or any voxel can be assigned specifically to a desired location or configuration. The porosity voxels can be used to add voids, open spaces, etc. based on the architect's or client's wishes.

Serious Design Game

The programmable framework for the urban scale multimodality is designed as a serious design game, intended to involve stakeholders from different professional backgrounds as level playing field co-designers. A number of 4 workshop sessions with a selection of architects, entrepreneurs and engineers [companies invited to participate were Manhave, ONL, New Citizen Design, RHDHV and Cepezed Projects] were held at the office of project developer Manhave in Rotterdam as to involve the stakeholders in the urban design game. Different spatial arrangements were explored, alternately set by the project developer, the entrepreneur and the architect. Highly unlikely spatial arrangements were introduced to discuss mutual relationships between the assignment of functions to the voxels,

helped the understanding of the full potential of the site, and certainly broadened the scope of the project developer, as he became aware of the necessity to aim at long term strategy to facilitate the interlacing of private life and professional business of the new citizen. While workplaces become flexible, lifestyles become more complex and differentiated in time and space, the designers of the built environment will have to cope with these new developments and hence will invent new time-based and spatial arrangements. The programmable framework for the urban scale multimodality stimulates forward strategic thinking and as such has proven its urgency as confirmed by the stakeholders.
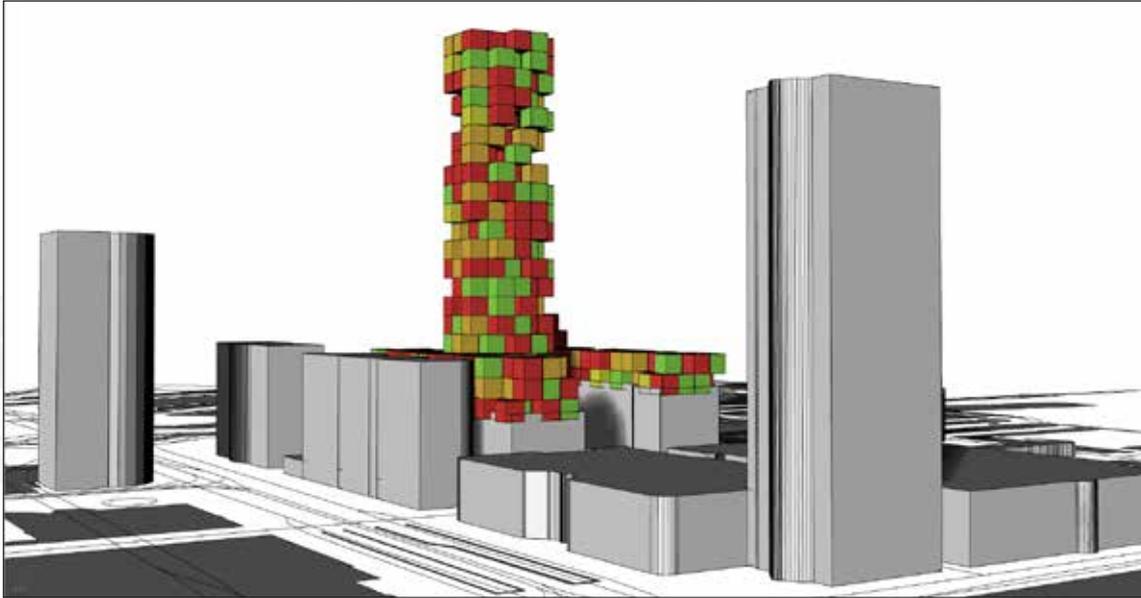
Figure 03: | ONL | Manhave urban design instrument | 2018 | random distribution of porosity and functions.

Technical Aspects of the Parametric Modeling Strategy

The programming of the design game for multimodality was executed in Rhino / Grasshopper. The general strategy that was followed was to set global and local parameters driving the constituting modules. The sequence of specification that was followed starts with selecting active reference points. Then these points are represented by a cube. Next step is to apply the level of porosity to the selection, where a randomizer selects the percentage of visible cubes. A porosity factor of 50% means that 50% of the selected reference points are visualized as cubes, in a random 3d configuration. Many cubes will seem floating as there is no cube under these cubes. Furthermore, we have introduced attractors to attract certain functions. The strength of these attractor determines the number of affected cubes, positioned within the zone of influence of the attractor.

Figure 04: | Workshop session #3 | project developer Steven Manhave verbally interacting with the design game.
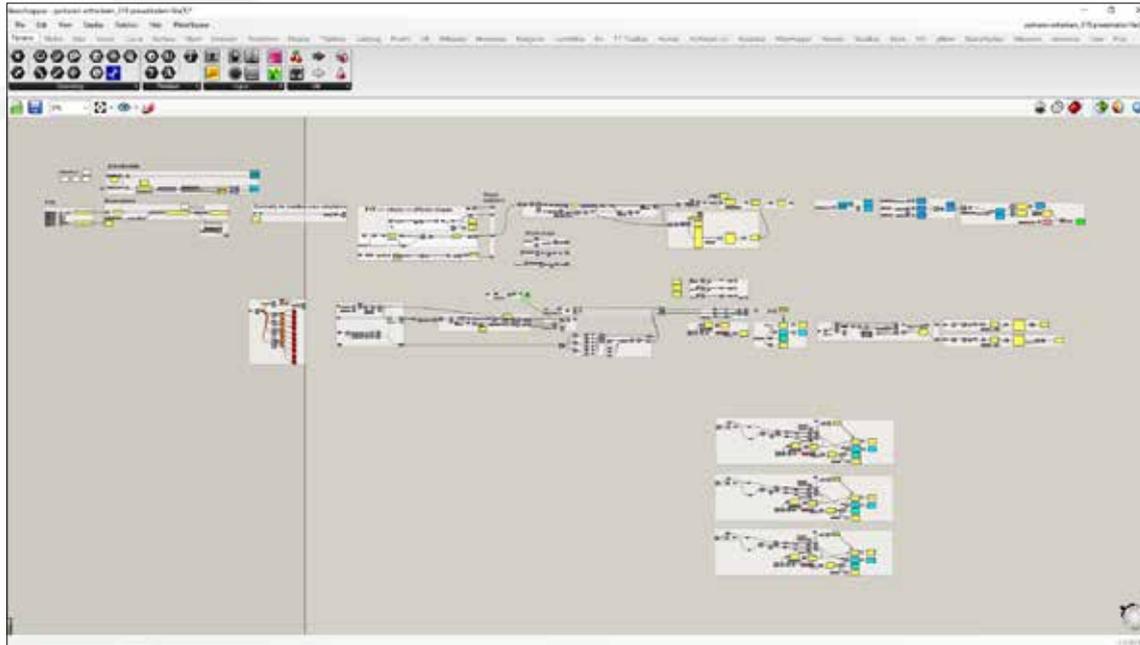
Figure 05: | ONL | Manhave urban design instrument | 2018 | programmable design environment.

Calculation

Having chosen the selection, set the porosity factor and the functional zones, many data can be abstracted from this model: total value of the selected voxels, surface area that is exposed to the exterior, floor area, shared wall area, sorted out within their specific functions. Tweaking the parameters, any change in the model is immediately recalculated as to have immediate feedback from choices being made. The stakeholders can test their own choices and have feedback immediately, in its full transparency to see for the other stakeholders.

Costs

Subsequently a cost unit is connected to the voxels to calculate the costs of the volumes, surfaces and the total development, based on data from practice. The cost unit is designed such that we can fix the total available budget as a target value, allowing the stakeholders to be guaranteed stay within budget, whatever choices they make. In the later stages of the development specific costs have been assigned to specific functions to enhance the reality factor of the developing master planning strategy.

Relative Position Towards Neighbor

At the request of the participating engineer, to enhance a realistic feeling for constructability another factor is assigned to the voxels, related to their relative position towards their neighbors. The rule that was inserted was that each voxel would look to its immediate neighbors. Having fewer neighbors would lead to higher costs, being surrounded at all sides by neighbors would result in the most cost-effective voxel. Also, that voxel would be less desirable since it has little or no view to the outside, and therefore only suitable for specific more indoor functions. Secondly, a structural analysis of the configuration provided feedback for the engineer. The consequences of the configuration are made visible by the visualized tension and compression through the initial shape. Based on the amount of tension and compression in the voxels the building costs estimation of the voxels are adjusted, high compression or tension voxels results in higher building costs. However, the voxels with less tension and compression are estimated to be less expensive to build.

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Multimodality

The multimodality of use of the spaces and the nature of the unfolded activity is related to their revenue, again based on experience from the practice of the stakeholder cq the project developer. Retail brings in more revenue than habitats per m2 / period of time. The position of the shop in de 3d swarms of voxels determines the details of the lease contract.

Ubiquitous Booking App

The system that underpins the flexibility in use in time and space of the voxels is based on an ubiquitous app. Via this app the customer choses place and time space of the lease. The unique aspect of the ubiquitous app is that one can book homes, office space, retails space for any period of time, ranging from ultrashort to ultra-long, and get immediate feedback from the system, including the contract. Not different from booking a flight, a hotel or a car, but now for space to live in, to work or spend quality leisure time.

Added Value for Green Spaces

As introduced by the social engineer, a bonus factor for green spaces adjacent to one's voxel is introduced in the parametric model. The immediate presence of a green space leads to a higher value of the voxel, they can be leased, either for shorter or longer periods of time, for a higher price. Especially the project developer validated this enhancement a lot, since it is often soft values that make up the potential profit in any project. The Participator design instrument supports the above features in real time.

Not in the Model

Intentionally not included in the model are elevators, stairs, fire safety measures, windows etc, as to keep the urban design tool strictly urban in its nature. They simply are taken into account as a percentage of the total volume and costs. The outcome of the Participator urban design game is the starting point for further development into an architectural model. In such further levels of detail, the integrity of the model and its intimate relations to the data must be maintained. When the urban model and the architectural model are developed as a further specification, always referring to its origin as member of the point cloud of reference points, any change in the chosen parameters in the very beginning of the project, like the chosen selection of reference points, must lead to an immediate change in the architectural model as well. When dynamically connected from concept design to design development, it is expected that an effectivity bonus of an allegedly 20% cost reduction in the design phase alone can be achieved with respect to traditional development of master planning and architectural models. Further cost reduction will be achieved when maintaining the integrity of the data in the subsequent phases to tender, contracting, execution and maintenance.

Goals and Objectives

The thus realized goals and objectives are to have a working participatory urban design instrument, designed to generate unexpected spatial and social configurations of clusters of functional voxels. The tool bypasses traditional biased prejudices of what is feasible, in terms of spatial arrangement, constructability and community building. No longer would an urban designer want to limit herself to a simple arrangement of earthbound solid blocks, arbitrarily fixing their height and function. The multimodal urban design instrument favors diversity in spatial arrangements, functional mix and in the social fabric. The participatory multi-player instrument effortlessly weaves diversity into a delicate 3d urban tissue, while securing precise data and outcome along the way of playing the serious design game. At all times the 3d geometry, the spatial definition and the social positioning must stay connected to the data, thus giving reliable and transparent feedback to the stakeholders.

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Glossary of Terms

A **point cloud** is a three-dimensional array of points in the 3d model, whether randomly positioned or in a regular pattern. The points have explicit coordinates and act as reference point for further manipulations of the geometry.

Baking in Rhino / Grasshopper software means exporting an instance of the parametric Grasshopper model to a static 3d model in Rhino. The baked Rhino 3d model can no longer be tweaked by the parameters as in Grasshopper.

Global parameters have effect on the whole parametric model, while **local parameters** only affect parts of the model. For example, a value for the overall number of units is a global parameter, while the values for the porosity factor act as a local parameter, while the porosity factor only changes the position of the units, but not the total number of units.

Attractors are the magnetic forces placed in the parametric 3d model. Attractors are linked to a specific object and have effect on other specific objects. In Participator, the attracting force is linked to the trajectory of the curves selecting the units in a tubular space of influence along the trajectory of the curve. The stronger the attractor, the larger the diameter of the active tubular working space.

Multimodality means that a certain spatial unit can be exploited in a variety of ways. In first instance, the units in Participator represent a volume without a specific function.

The term **participatory** is in itself self-explaining, yet might need some further explanation. A participator is not someone who just attends a meeting, but someone who is a decision maker. Participating means being actively involved in the decision process, a co-designer playing the design instrument throughout the whole design process.

Participator is a **multi-player** serious design game, meaning that there is a team of players working together to reach the goal of creating a shared vision for a certain urban design task. The players are not competing with each other but collaborating together. The reward of playing the design game is an urban design scheme that would not have been possible in a single player design process.

The Body at the Center of Our Design Universe

Mark David Major[1], Heba Osama Tannous[2]

[1]Assistant Professor of Architecture and Urban Design
[2]Research Assistant, Department of Architecture and Urban Planning
College of Engineering, Qatar University, Qatar
m.major@qu.edu.qa, heba.tannous@qu.edu.qa

Abstract

A third factor has increasingly complicated the man-environment paradigm – the intellectual and physical framework defining the relationship between man and the environment, both built and natural – without definitive resolution since the mid-18th century. This is the man-machine paradigm, originating with Industrialization but transforming into new, unfamiliar forms with the digital revolutions of today. Our technological prowess and ingenuity as a species always seem to outrace our sensibilities, especially the most common kind, in the (sometimes-blind) pursuit of fame and fortune in modern capitalist societies. This is to be expected and even encouraged. However, we must always guard against the worst evils of human nature in this race. We are imperfect beings. Our machines will always be similarly imperfect. The built environment can be a wonderfully adaptive mechanism for the collective good but it alone cannot compensate for – and even disproportionately suffers from – the ill-advised design judgment of individuals. Given these circumstances, we will review some basic design principles to hold firm while doing better for our built environments of the future with a little foresight.

Keywords: Machine; Human; Body; Environment; Design

Frontispiece: Leonardo da Vinci's *The Virtuvian Man* (Image: Gallerie dell'Accademia, Venice).

The Man-Environment-Machine Paradigm and its Dilemmas

Since the dawn of Industrialization in the mid-18th century, we have struggled with the alternations necessitated by the machine to the man-environment paradigm, which is the intellectual and physical framework defining the relationship between man and the environment, both natural and artificial. Marc-Antoine Laugier's (1755) *Essay on Architecture* – itself largely derived Vitruvius' 15 BC treatise *De architectura* – identifies 'the primitive hut' as the intellectual and practical origins of architecture itself, found in the basic need for shelter because of this paradigm (**Figure 1**).
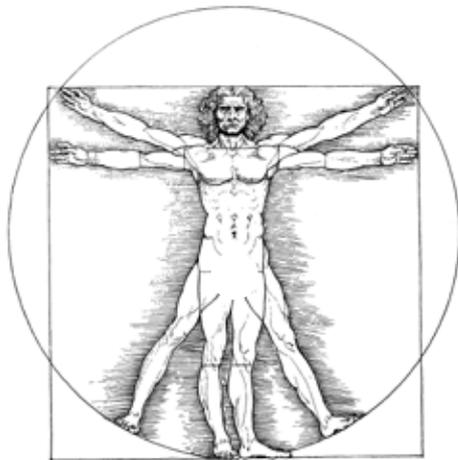
Figure 01: Charles Eisen's allegorical engraving of the Vitruvian primitive hut in the frontispiece of Marc-Antoine Laugier's (1755) *Essai sur l'architecture* (Image: Wikipedia) [Emphasis added].

The emergence of the International Style in the late 19th and early 20th century was a radical attempt to address the most urgent implications of the machine for architecture and urbanism; namely, mass production, standardization, and its consequences for design aesthetics. It was only partially successful, mostly in terms of economy. Ironically so, one might argue given the inclination of many Modernists for the economic and political models of socialism. Over the last century, Modernist design and planning principles have proven incredibly adaptive and resilient as a profitable engine of capitalism around the world. However, as many argue, Modernism was also a dismal failure especially with regards to issues of livability in the built environments of our cities (Jacobs, 1961; Stroup, 2005; Gehl, 2010, 2011; Speck, 2012). We have spent a century surrendering our cities on the Modernist altar for one machine in particular: the automobile. The negative consequences have been obvious for many decades now, giving rise to counter movements such as the Congress for New Urbanism in the United States during the 1980s/1990s even as reactionary movements such as Post-Modernism in the 1960s and Deconstructivism in the 1980s arose to address the perceived loss of aesthetic meaning in architectural form itself. As American architect Robert Venturi famously said, "less is a bore."

Since then, we have been engaged in 'a losing race' to recover from the errors of Modernism. We are losing the race because of rapid urbanization around the world at an unprecedented rate in human history. In 2015, 54% of the world's population lived in urban areas. Another 2.5 billion people are projected to live in urban areas by 2050 representing 66% of humanity with 90% of that increase expected to occur in Asia and Africa alone (UN Department of Social and Economic Affairs). The seemingly unstoppable twin locomotives of capitalism and Modernism are feeding this rapid urbanization. Many argue capitalism itself is the problem. The Wikipedia entry for "Criticism of capitalism" in its series on *Libertarian Socialism* cites no less than 100 credible sources and more than 175 external links to concepts, economics, people, philosophies and tendencies, significant events, and other related topics promoting this viewpoint. From A-to-Z, they range from "Anti-(insert here)-ism" to Howard Zinn, an American historian who describes himself as "something of an anarchist, something of a socialist. Maybe a democratic socialist"; an 'all of the above' characterization notable for including almost everything except capitalism and fascism (Glavin et. al., 2003). There appears to be some degree of political expediency to this viewpoint since it ignores the astounding improvements in the human condition, which can be credibly attributed to the spread of capitalism (in particular, neo-liberal economics) since the fall of the Berlin Wall in 1989 and the Soviet Union in 1990 as well as the effective collapse of Communism almost everywhere on the world stage except for a few isolated locations. There has been a 50% drop in the poverty rate and infant mortality rates and a 50% increase in female education around the world (Source: World Health Organization/United Nations). Despite its many flaws, capitalism has repeatedly proven itself to be an effective economic and political engine for improving the human condition. Instead, the flaw appears to lie within Modernism itself; in particular, the design and planning principles of the International Style. Even as American and Europeans struggle to reject and/or modify into new architectural forms the inhumane built environments of Modernism, the prevailing institutional and business entities advocating this model of architecture and urbanism has been busy exporting it around the world to accommodate the rapid urbanization of the last 30 years. Conveniently, it is a 'known commodity.' We know how to do it and how to quickly profit from this model even if we are acutely aware of the flawed results. China is already suffering the consequences of implementing Modernist design and planning principles (i.e., high-rise towers in a park setting, surrendering streets to the wide, high-speed automotive corridors, etc.) in the creation of entirely new cities, constructed so rapidly to accommodate rapid urbanization in the world's most populous country that they almost seem to appear overnight.

If resolving the dilemma of a new relationship between man, machine, and the environment seemed urgent to the Modernists in the early 20th century, it has evolved into a readily apparent emergency during the early 21st century. As new technologies arise from our machines and we continue the digital revolution

some refer to as the 4th Industrial Revolution – meaning a fusion of technologies blurring the lines between the physical, digital, and biological spheres, collectively referred to as cyber-physical systems – new challenges are already presenting themselves for the design of our built environments even as we fail to correct and even perpetuate the old errors. As a consequence of this revolution, some philosophers and scientists even argue that the species of *homo sapiens* (meaning 'wise man') will be extinct within many of our lifetimes, i.e., the next 50 years (West, 2017). In this regard, humanity stands on the precipice of our next dramatic leap forward as we fully merge with our machines and evolve into the new species of *homo cybernetic*. Evidence for this evolution already abounds in our world. We remain almost perpetually linked to our smartphones. We replace various parts of our bodies with increasingly sophisticated artificial mechanisms. However, the evidence has been present for more than a century, if we date back to the creation of crude prosthetic limbs for maimed veterans of the US Civil War in the 1860s (**Figure 2**).

Figure 02: (Left) The Ascent of Homo Cybernetic and (right) prosthetic limbs for a maimed veteran of the US Civil War in the 1860s. (Images: Mark David Major/Hanger, Inc.).

It seems likely that this evolution will dramatically transform the moral and ethical compass of humanity, perhaps in unintentional ways. As Jonathan Haidt (2012) argues, humans "are 90% chimpanzee and 10% bee." This means we are driven both by individualistic and collective impulses with the chimpanzee representing the former and the worker bee representing the latter. Could the evolution of homo sapiens into homo cybernetic radically alter this balance of the species and mark the dawn of a new collective consciousness where our individualistic impulses – the very basis of the economic and political system of capitalism – becomes submerged, even eradicated (along with free will) in favor of a form of cybernetic communism? While this might have appealed to Karl Marx and his most devoted acolytes, it seems likely that the vast majority of people in the world today would view this futuristic vision with abject horror. Our new technologies raise profoundly disturbing questions about the very nature of human ethics and morality; something long left to the purview of religious faith. These are questions that many scientists and entrepreneurs do not want to face in their blind pursuit of long-term fame and/or short-term profit as innovators.

This is if the creation of artificial intelligence does not destroy us first. Noted physicist Dr. Stephen Hawking, author of the bestseller *A Brief History of Time: From the Big Bang to Black Holes* (1988) cautioned before his death that the "development of full artificial intelligence could spell the end of the human race" (Cellan-Jones, 2014). Hawking's warning could be interpreted as the doomsday scenario where artificial intelligence rises to destroy its creators. We have already imagined this scenario numerous times in literary and film fiction; perhaps most famously in James Cameron's 1988 film *The Terminator* and its sequels. Fiction is quickly becoming reality as scientists endeavor to incorporate some version of Isaac Asimov's Three Laws of Robotics in the pursuit of artificial intelligence to alleviate the probability of this doomsday scenario (Asimov, 1950). Relying on a circular logic to avoid circumvention, these three laws state:

1.   A robot may not injure a human being or, through inaction, allow a human being to come to harm.

2. A robot must obey orders given to it by human beings except where such orders would conflict with the First Law.

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

However, it should be relatively clear this does not preclude an artificial intelligence from taking actions contrary to human free will in pursuit of fulfilling these laws in the best interests of our species. For example, these laws would allow, even compel a robot and/or artificial intelligence to forbid a human being from smoking tobacco or drinking alcohol based on the greater probability of that human causing harm to the self- and/or others. In this case, the doomsday scenario remains a possibility through subjection instead of outright destruction.

We can also interpret Hawking's warning to mean that artificial intelligence will form a critical component in realizing the merging of man and machine in the new species of homo cybernetic. This is more likely what Hawking originally intended with these comments. Of course, this precludes the possibility that we are already living in a simulated reality as argued by some scientific philosophers and industry leaders such as Tesla's Elon Musk (Anthony, 2017). This raises the prospect of a profound ethical and moral dilemma. It implies that the nature of insanity itself is 'playing by the rules' of the simulation. Whatever or whoever is controlling the simulation and dictating those rules, it seems reasonably safe to conclude that the entire artifice of human ethics and morality as most commonly understood – with its origins in the social collective; principally religious faith and institutions – are part of the rules of the simulation. This indicates those people refusing to play by the rules – mass murderers, serial killers, sociopaths, criminals, and so on – might represent the true models of sanity *within* the simulation. It is difficult to know how this can be scientifically proven or even if we should try since it would lead to the total collapse in human civilization if ever accepted by the vast majority (or even a substantial minority). This notion inevitably leads to nihilism, which is the rejection of all religious and moral principles in the belief that life is meaningless. Nihilism is a philosophical cul-de-sac. More than this, even our most fevered fictional imaginations of immersive simulated environments have to make allowances for the human body lest they strain credibility. There is no better example than the Wachowski Brothers' seminal film when the main character Neo (Keanu Reeves) awakes from the immersive simulated reality of *The Matrix* (1999) in which most of humanity is unknowingly enslaved by their machines (**Figure 3**). Even under these conditions, machines controlling the simulation have to make allowances for the fragility of the human body to maintain control, even liquefying the corpses of the dead to intravenously feed to the living as stated by the character Morpheus (Laurence Fishburne).

Figure 03: Neo (Keanu Reeves) awakes from the immersive simulated environment of *The Matrix* in the Wachowski Brothers' 1999 film (Image: Warner Brothers).

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The Machine and our Fragile Human Bodies

We have become exceedingly good at designing machines to the comfort and use of our bodies. In this regard, design advances are almost completely egocentric in nature, catering to our 'chimpanzee qualities' as a species, conforming the machine to the individual user (Haidt, 2012) (**Figure 4**).

Figure 04: (Left) Luxurious interior designed around the human body in the 2016 Mercedes-Maybach S600 and (right) bull bars on the exterior of a Japanese Sport Utility Vehicle (SUV) at the peril of the human body (Images: Flickr).

One must only view the first-class cabin of any major airline and/or the carefully crafted interior design of any luxury automobile (with its abundance of cup holders) for confirmation of this fact. In no small part, Apple, Inc. became the first US trillion-dollar company in 2018 due to its uncanny ability to take well-established technologies (portable media players, phones, and watches) and design user-friendly interfaces (both physical and digital) for their machines such as the iPod, iPhone, and Apple Watch. At the same time, we have been much less successful about designing such machines from an allocentric point of view catering to the social being of our 'bee qualities' as a species (Haidt, 2012). Despite the moniker of 'social media', it has become increasingly clear that our obsessions with these machines lead to social isolation and outcomes that are (unintentionally) anti-social in nature (**Figure 5**).

Figure 05: Sign encouraging patrons to talk to each other at Noodles & Company in Grand Rapids. Michigan USA in 2016 (Images: Flickr/Steven Depolo).

We persist in designing our machines with little or no regard for the potential damage to someone other than the individual user (i.e., external to the machine) and, sometimes, to that individual user as well. For example, the possibility advocated by many in the medical field that cell phone usage increases

the probability of certain types of cancer or other health problems such as malignant (cancerous) brain tumors, non-cancerous tumors of the brain/salivary glands, and nerve damage to the ear (Source: American Cancer Society). We also continue to place devices like bull bars on the exteriors of our automotive machines even though they do practically nothing to enhance the safety of the vehicle or passengers (refer back to Figure 4). However, they have an undisputed capacity to turn a minor injury into a major disability and a major injury into a fatality for a pedestrian. We persist in these behaviors for mere aesthetic reasons and/or some misplaced perception of masculinity and power associated with such accouterments. We even have an entire class of automobiles designed and nicknamed on such a basis, i.e. muscle cars. It is perhaps telling that we do not have any class of automobiles designed and nicknamed based on the perception of femininity for their nurturing qualities as a machine, i.e. breast cars. The Volkswagen Beetle might be the most obvious candidate for such a class of cars due to its distinctive shape and renowned reputation for remarkable longevity.

More importantly for the built environment, we persist in designing and planning our cities around these automotive machines for the exclusive purposes of speed and storage even though the cataclysmic results on people and urbanism have been known for decades (**Figure 6**).

Figure 06: "Death Every Quarter Hour" article in the 7 July 1958 issue of *Life Magazine* (Image: Time-Life).

By now, we are all broadly familiar with the frightening statistics. Automobiles kill nearly 1.3 million people around the world each year. Automobiles injured or disable an additional 20-50 million people each year. On average, automobiles kill 3,000 (3,287) people every day; more than half of which are people under the age of 44 and more than a quarter are people under the age of 25. Automobile crashes are the leading cause of death for people under the age of 29 (Source: Association for Safe International Road Travel). Automotive genocide is primarily due to traffic engineers and urban planners long ago confusing and merging the nature of speed with that of flow in the design of our streets (**Figure 7**). This is a fundamental mistake that is only now beginning to be corrected in urban design and planning but at a rate that falls far behind our rapid rate of urbanization around the world. The mistake only seems to perpetuate itself *ad infinitum* despite our best efforts.

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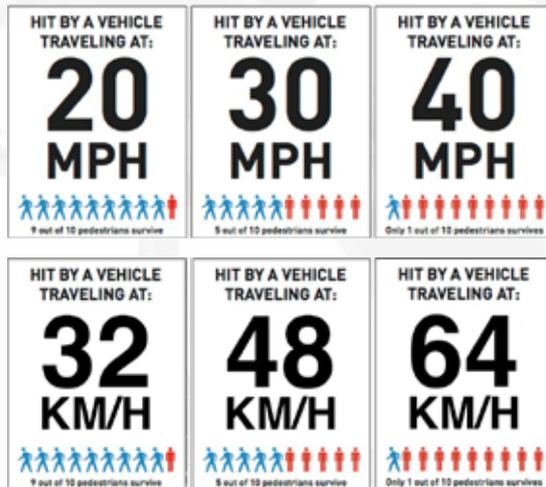
Figure 07: Increased probability of pedestrian fatality with speed in (top) miles per hour (MPH) and (bottom) kilometers per hour (Image: Vision Zero Network/Mark David Major).

Figure 8. Multi-level highway overpasses serving the machine in Shanghai, China today (Image: Flickr).

In the process of perpetuating this automotive genocide on a grand scale, we have committed urban genocide for decades by making large swathes of our cities largely uninhabitable for human beings (**Figure 8**). We waste a vast amount of space on these machines in every city of the world even though automobiles spent +/-95% of their lifetime doing absolutely nothing, i.e., parking (Stroup, 2005). An automobile driven 400,000 miles (<644,000 km) in 8 years will have an average speed of only 5.7 mph (<9.2 km/h) over its lifetime. This has led to rising movements to slow down automotive vehicles based on the premise that low speeds are irrelevant as long as the vehicles continue to flow. This includes increased use of roundabouts (especially in the United States where drivers are long-accustomed to stopping at the four-way intersection), several Shared Space (i.e., elimination of modern roadway sections and signage where pedestrians and vehicles are compelled to self-regulate their behavior) and Tactical Urbanism (i.e., temporary design alterations to demonstrate viability) schemes in Europe, the United States and elsewhere in the world, and increasingly important advocates of "20 (mph) is Plenty" or "Love 30 (km/h)" at the local neighborhood level of cities in the United States, Europe, and elsewhere. In no small part, these transformations are occurring due to decades of research about cities by such people as Jane Jacobs, William Whyte, Jeff Speck, and Jan Gehl; the last two of which have been almost relentless in advocating cities for people, not things (Jacobs, 1961; Whyte, 1980; Gehl, 2010, 2011; Speck, 2012).

These fundamental transformations in our cities are occurring but in danger of being lost due to the mad rush towards the Age of Autonomous Vehicles (AVs) where automotive and traffic engineers, urban planners, and oligarchic corporations are repeating the same mistake of confusing speed and flow in the design of transportation systems. The consequences are eminently predictable with a little design forethought and fundamentally tragic with a lot of hindsight: well-publicized instances of AV crashes, (temporary) retreating of corporate AV research initiatives to rethink their strategy, and even a pedestrian death in the case of Uber's AV testing efforts in 2018 (Levin & Wong, 2018; *The Guardian*, 2018). This appears further complicated by the assumption of some AV researchers about the universality of smartphone and Wi-Fi technologies necessary to enable to this bright AV future. However, not everyone can afford the latest smartphone technology. These technologies require constant updating for maintenance, which some people are slower to implement than others, if at all. There is an arrogant presumption at work in some of this research, which seems to be that these concerns do not matter – or can be worked out later when the profits and problems become

real – because only the most vulnerable in society and our cities are at risk. This has been the *modus operandi* of the automotive industry for decades; profit now, apologize later. As a species, we should really hold ourselves, our machines, and our cities to a higher standard than mere convenience.

The machine, the built environment, and us

Academia and the profession promote and value the pursuit of the innovative, the next big thing in architecture, i.e., 'Oh look, shiny object!'. In architecture education, this is as it should be for developing the creative design and critical thinking skills of the next generation of architects and town planners. Architecture education affords an unprecedented degree of creative freedom to the student for design exploration and critical self-evaluation, which is only rarely welcome in the real world. Design projects have to meet requirements, budgets, and schedules in service to the client as well as adhere to the physical laws of the universe. The downside of this approach in architecture education is that it ferments an egocentric view ('unique to each') of our built environments and cities as designed objects. It feeds on that 90% individualistic (chimpanzee) quality of our nature – sometimes ravenously, to the exclusion of all else – both in how we create and value the architectural and urban object… and its creator (Haidt, 2012). In doing so, we too often lose sight of the other 10% bee quality of our human nature as social beings; more so in architecture academia than in the profession where social and economic realities usually impose some necessary limits on the architect to realize the architectural and urban object. In the process, the critical thinking skills that some architecture educators work so diligently to imbue in their students ('Am I correctly looking at this object and do I understand why it is shiny?') often fall by the waste side under the onslaught of popular culture in architecture. In pursuit of the BIG IDEA, we overlook the small details. Historically, the results are sometimes disastrous for the profession and the community. The most obvious example is numerous failed Modernist social housing experiments and highway constructions devastating neighborhoods in cities around the world. Fortunately, there is a societal feedback loop correcting for such mistakes even though it usually takes a long time, perhaps decades to recover from the mistake (**Figure 9**). The failed architectural or urban object falls into obsolescence and eventual demolition. We replicate the successful ones over and over again to become part of the architectural vernacular (Rossi, 1982). However, the initial design and planning mistakes could have been avoided altogether with a little forethought. This is because in pursuing an egocentric view of our built environments, we often lose sight of what is truly remarkable about them, especially our cities, which is their allocentric nature ('common to all') as physical objects in the real world.

Figure 09: Before (left) and after (center) views of the Cheonggyecheon urban regeneration in Seoul, South Korea; and (right) demolition of the Pruitt-Igoe Public Housing Project in St. Louis, Missouri USA in 1976 (Images: Reuters/ Bankoo/Shutterstock/State Historical Society of Missouri).

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Figure 10: Figure-ground representation (space in black, blocks in white) of a one square kilometer (1 km²) area of urban fabric in 25 cities around the world (Image: Mark David Major/ARCT 210/DAUP).

It is at this allocentric level that we implement (sometimes intuitively) the most basic and generic things about ourselves in the built environment and cities. By far, it is almost the most powerful aspect of architecture for fermenting functional success in the replication of our created objects so they eventually become part of the vernacular and avoid the obsolescence and demolition of a failed architectural experiment. All cities are predominantly composed of streets and blocks (**Figure 10**). Truly understanding the city means understanding its allocentric nature, most commonly found in its streets and blocks. We can and should always strive to understand what makes each city distinctive (or egocentric in terms of the uniqueness of culture) but we must be careful to always embed this knowledge within the larger context that is common to all based on the most fundamental truths of our nature as a species. This is because the most generic thing that all cities have in common is *us*: the fragile, bi-pedal, forward-facing human with opposable thumbs and a near-bilateral symmetry who is bound by gravity (**Figure 11**). We even design and operate our machines within the confines of these narrow parameters. An automotive vehicle or an airplane may be able to move in reverse (just as we are able to move in reverse) but these machines and we rarely move in reverse for more than a few feet or meters. An airplane may be able to temporarily (never perpetually) escape the bounds of gravity for the purposes of air transportation but we as the passengers are still bound by gravity during that transit except for only during most extreme of temporary circumstances, i.e., an accidental or purposeful vertical dive.

Figure 11: Our Client: the fragile, bi-pedal, forward-facing human with opposable thumbs and near-bilateral symmetry who is bound by gravity (Image: Big Stock).

Our bodies, our machines, and our built environments exist in the reality of this physical universe. No matter the far- or near-future of our species, this is extremely unlikely to change anytime soon. The second law of thermodynamics is a universal constant, which states that total entropy of an isolated system can never decrease over time. This means entropy increases or, more simply, the more you put things back together, the more they fall apart. Even if the anticipated evolution of homo sapiens into homo cybernetic occurs in the next 50, 100, or 500 years, we will still have to maintain our bodies (even if they might prove less fragile), and design/maintain our machines and our built environments to match these conditions. Our bodies must reside within (egocentric, internal to) *and* without (allocentric, external to) of our machines and built environments. As architects, urban designers, and town planners, we must always strive to successfully balance the demands of our machines and built environment with the demands of our bodies but never place the former above the latter. Placing the human body at the center of our design universe goes a long way towards addressing the issues that past generations have struggled and failed to resolve. We can resolve this dilemma for our generation and future generations, whatever their eventual form and nature.

Conclusion

We reviewed a third factor complicating the relationship between man and the built/natural environment since the dawn of Industrialization in the mid-18th century: the machine. We argued it is crucial to not allow our technological prowess and ingenuity to race to too far ahead of our design sensibilities as a species. We are imperfect beings so our machines will be always similarity imperfect. We do not have to settle for these imperfections (even fatal ones) in the blind pursuit of fame and fortune. We do have the ability and knowledge (some based on ancient wisdom) to mediate for these imperfections in developing more adept machines and more livable communities in our cities. This is the strength of the built environment as a physical, economic, and cultural mechanism in human society. To accomplish this, we have to avoid ill-advised design and planning decisions, which places something other than the human being – and the human scale – at the center of the design process. In doing so, we can and should do better for our built environments of the future, no matter the evolutionary course of our species.

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Increasing Value of Architecture in the Platform Society

M. N. Pool

Director Space & Matter

pool@spaceandmatter.nl

Abstract

The author has developed several methods for democratizing the architectural design process resulting in a more user specific and open architecture. Our cities need Open Systems in order to grow and become resilient and not rigid ones. People should be able to change the environment they live in, the longer they live in them. The city's Eco-System is about equilibrium and balance, for a city to evolve, this balance is important. The city needs to remain open and unpredictable in order to be resilient. This paper describes which Open Process and tools result in creating Open Buildings. The authors mission to aim for an Open City is being described by implemented case studies. The author's experience and theoretical framework is being developed synchronously. Since architecture and urban design touches on all levels of society, space&matter involves a wide spectrum of disciplines in their design and development process. Before configuring space, understanding socio-cultural processes adds relevance to our designs; our objective is connecting people and their environments. In order to reach a high level of connectivity in the built environment it's relevant to Open up the Design Process. Experts, stakeholders and also end-users can collaborate in the process of creation from an early stage. This makes our architecture more specific and more sustainable.

Keywords: Democratization; Self-organization; Community building; Open system; Inclusivity

The Value of Architecture; Capital no Capital

Seeing the influence of Capital on architecture. To what extent does the availability of capital result in good architecture? As architects are complaining about the lack of budget, how can one make good architecture if there is no availability of an adequate budget? But if there is an unconstrained amount of capital, is does not stimulate nor generate good architecture. What is the good condition for architecture to emerge? And what is the influence of Capital? For example in London – empty urban districts, which actually represent the mere storage of Russian Rubles or Chinese RMB's, the real estate stock as a safe haven for foreign capital to be stored. The actual value of the residence, the place it is built in, the atmosphere it breathes is not gained. The static and latent stock of monetary value is sucking out the societal value out of the neighborhoods… leaving an alienated neighborhood.

Das Kapital is a Book by Pikkety explaining the influence of capital on the distribution of wealth. The basic message is that the inequality between 'haves and not haves' will increase. The ones that have or have access to *Kapital* are able to gain from the growth of capital. The ones that don't have capital will have to be employed. But being employed means paying rent for a residence and services. While prices increase; the current generation will not be able to build up capital. How can we make the city, the buildings, and thus the architecture less dependent on capital? There is a lot more value out there than monetary value. So let's start talking about value and not money.

Design and Development tenders aiming at the submission of the highest bid, cannot result in the highest quality of architecture. What is the aim of opening up calls for the highest bid? What if the highest bid needs to be translated as the bid proposing the highest value? The highest value should be seen as the highest total value. Value is more than the monetary explanation. Value is not singular nor one-dimensional. Value is a complex matter composed of interpretations and acceptations. The

cultural value or historical value are strong parameters to be judged. But also social value; the societal value in terms of amount of jobs created. Or the educational value; every project is an important learning potential. Taking an inclusive approach to value, will also require a more inclusive approach to proposing a call. We believe in the value of communities, the value that every individual represents. A collection of individuals is a rich pool of talents and skills. We see an architecture that can emerge from the social capital of the residents that inhabit it. Like a co-housing project that is co-funded by it's future owners. No developers and no investors are necessary in the process…

Hope and Perspective

Building cities on the foundations of social capital makes them the breeding ground for long lasting strong networks of connected individuals. Groups and collectives respect each other and are generous. Stimulating environments in which an individual's talent is seen as the maximum potential to be exposed and creating urban conditions in which this is optimally orchestrated should be seen as Practical Utopias. Making ideological vision into hyper real and tangible proposals. Making concepts, drafting strategies and thinking about activist interventions all have the strong focus and goal to establish the condition for happier communities. A high sense of belonging is an important ingredient, the degree of participation in the process, the level of trust and reciprocity. The social capital is our largest asset and can be multiplied if we are capable of envisioning and concretizing the HappyCity.

Building cities on the foundations of trust will foster communities with thriving happy people. Happiness emerges when people feel connected to each other and to their physical environment. There is no more crucial ingredient for human happiness than strong, positive social connections. Connected communities are happier, more resilient in hard times and better equipped to handle economic challenges.

Problem Statement

Entering the 21ˢᵗ century has brought us a lot more wealth, more independence, more devices to assist us in our well-being. But at the same time it has made us more independent and actually more disconnected. The automobile is an individual cocoon extracting a person from the public life in the street. The mobile phone is creating a digital bubble the individual can escape in. The devices, the autonomous behavior, has increased our independence, yet has made us more isolated… We see an enormous increase in the disease of loneliness in cities. We feel we are part of a crowd, but feel lonely and impersonal. We live very closely together, but are segregated at the same time. We live in parallel realities. How can we embrace all the benefits of 21ˢᵗ century inventions and technologies to make our urban environments more Inclusive? Not a high level of wealth, but feeling rich with the amounts of friends we have… Feeling rich because our talents can be deployed. Feeling rich, because we are free. The freedom of not living with the burden of a mortgage and the ownership of too many goods. Foot-loose living…? Do we have to go back in time and look at nomads? Living within the direct context and co-existing with the resources the context and the season provides.

1. Making Inclusive Cities

A City's evolution was based on clusters of people that functioned well in balance with their direct natural resources, which was also a limitation for its growth. The industrial revolution and especially the start of the coal era made the city free to expand. Railways, roads and bridges made sure the city's reach goes far beyond its hinterland. This is where the city as an organic self-organized ecosystem got out of balance. Nowadays we see the city function as nodes in a very well connected network of cities. These networks develop fast and their scale and complexity rapidly increase, while there are acknowledgements for negative environmental effects. The Connected City sees opportunities for an Imploding City rather than an Expansive City. While cities continue to grow we don't need its physical

substance to increase. As designers we aim at contributing to the built environment by providing holistically designed structures that incorporate flexibility and adaptability from an early stage in the design process as well as throughout the life-cycle of a building. We rather see buildings as collective resources, which can be used more effectively in order to cater for societies' expanding needs. Seeing the City as an Open System makes us think about the buildings as Open Buildings functioning in this Open System. Design and planning incorporates thinking about organization; through networks, a high level of self-organization can be reached.

Cities accelerate economic transformation because of their intense population densities, which encourages social and economic interactions with greater social friction than non-urban settings. An estimate says that 54% of world population lives in cities; by 2050, the percentage is expected to reach 66%. City dwellers have 30-50% smaller CO_2 footprints than rural and suburban residents. If so many people live in cities, then it's important that city making is done in close collaboration with all actors, especially urban dwellers. If city planning is not inclusive, people might start to feel that its useless to take action. The planning process and outcome must be socially inclusive; marginalization of groups of urban actors must be prevented (Timmeren, 2015). In our research we aim for the Inclusive City, in which a direct interaction in the creation of the built environment is crucial. Facilitated through an Open Process, the realization of Open Buildings is effectively and innovatively taking shape. On the basis of the research of multiple case studies the author provides knowledge and understanding of methodologies and tools contributing to empowering citizens in shaping their city. The Open City vision underlying these methodologies revolves around self-organization, Open-Systems, platforms and collectivity in the understanding of the Commons. On the basis of the Networked Society, the Networked City will become the Inclusive city.

1.1 How Intelligent are Smart Cities

Smart Urban development opens up new opportunities at the crossroads of the physical and the digital aspects of the urban domain, resulting in solutions that could fundamentally transform and accelerate the development of cities as well as their ability to change. In order to function well as smaller networked environments it is necessary to increase the level of diversity and connectedness. Heterogeneous programs and close-knit networked environments are more capable to reinvent themselves and to be resilient for change. The concept of resilience is seen as a useful way of understanding, and explaining, how social-ecological systems respond to change and disturbance. It is also seen as a desired attribute of cities in modern urban planning and management strategies. A focus on resilience and the resulting strengthening of the self-organization capacity of urban systems is also regarded as a means of improving the sustainability of cities (Gibberd, 2013). Diversity and adaptability are strong contributors to a city's well-balanced Ecosystem. The level and scale of diversity is furthermore discussed in relation to Openness. This paper aims at creating an understanding of how the Open City and Open Buildings can be more resilient, and perform better in the continuous process of transformation in an evolving and changing society.

1.2 Use of Open Systems to Create Connected Cities

The Open City as an Open System however is evolving as a system of constant change and providing a test-bed for experiment and innovation. ICT and the internet have allowed people to communicate with each other more than ever before, yet leaving many people with an increased sense of uncertainty, anxiety, isolation and alienation (Timmeren, 2015). The more we rely on impersonal modes of digital communication the more we may be loosing the intimacy and depth of social and physical correspondence. In order to rebuild this relation, people need to connect to their physical environments and to their social structures and networks within their environments from which we have grown

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detached. The increase in independency because of communication and mobility has diminished the physical connectivity and replaced it with a high level of virtual connectivity. (Grillo, 2005).

The question of what we want our future urban spaces to look like cannot be separated from what kind of people we aspire to be. We must go beyond the individuals' right to have access to the resources the city provides, towards the right to change and re-invent the cities (Harvey, 2014). The freedom to make and remake ourselves and our cities is the most precious yet the most neglected of our human rights. (Robinson, 2013). *The illuminated City* as Arjan van Timmeren refers to is citizen-focused, community defined, open-source cities that harness technology to enhance democracy and distribute governance, support individual and collective autonomy, community participation in urban planning and enshrines the citizens right to privacy.

Democracy in the Open City is a situation where the facts, beliefs and practices of society are forever examined and confronted. For it to flourish; spaces of confrontation must exist and contestation must occur. Study of networks is complexity theory, in which one very essential concept is the Complex Adaptive System (CAS) and its characteristics of emergence and self-organization are described. Taking action will also result in Reaction, on micro and macro level that is what makes the city work. As long as there is a sense of ownership and the ability to participate and take action; one possesses the feeling of belonging and being part of the city. This also attaches an individual to the collective identity of a city. If all relevant stakeholders are included and heard than the social capital which is drawn upon is largest. The higher the level of diversity of the social and cultural capital, the higher the increase in adaptive capacity, which enhances resilience in the face of external shocks and rapid change.

Figure 01: Values of connections and social capital.

Case Study: Open City Planning Model

Towards urban planning the conventional masterplan is dismantled and replaced by a more organic model of interactive city making. In the Open Kaart proposal, Space&matter has moved from a tactical urbanism to a strategic urbanism by facilitating an emergent model to express the city's latent desires. This means that we as designers are not 'master planning' an urban district, but rather provide a stimulative framework within which substantial degrees of freedom are generated. Stepping down from a top-down master's perspective we facilitate the users perspective and lower the threshold for individuals to be part of city making, as well as collectives and not to forget the professional and institutional parties. Doing so we provide a level-playing field for multiple actors to give expression to their desires. The Open Kaart model consists of a simple set of rules and guidelines. On a macro level infrastructure, green axis and routing has been determined. The 'infill' of this so-call urban 'structure' is provided by tangible building envelopes and subdivision of plot sizes. The scale and proportion of one's

interest is fostered by the plot size and the prescribed capacity of the potential development. As such the city planning process has become a collective act. Especially for the individual the large degree of freedom is combined with affordability since it's open for real people, with real houses, funded by real money. By providing a greater diversity of engaged citizens a stronger social fabric is established.

Figure 02: Open Kaart Attributes; site, building envelopes, configuration.

Figure 03: Open Kaart: open planning toolkit.

Case study: SchoonSchip Amsterdam

Schoonschip envisions the design & development of a Resilient and Circular Floating Community. Space&matter has catalyzed the group clustering process by providing feasibility studies and visualizations. In close collaboration with the group, we developed the urban plan consisting of 30 houseboats, housing 46 families along a 900-sqm jetty. The floating neighborhood is divided into 5 interconnected clusters. The jetty forms the backbone for the floating community. It serves as public space and creates unity in the urban design. Its specific form allows rotated positioning of the houseboats and therefore better views and visual connections. To meet the diversity of the group and to promote variety in architecture, we developed 5 houseboat typologies of various size and shape. For each typology we created a set of rules and defined the maximum building size so that each household could easily instruct

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their own architect. The Open City approach in this project has been very successful, since it allows high degrees of freedom for the individual while realizing a strong collective identity.

Figure 04: Schoonschip: floating, self-supportive neighborhood based on autonomous city making.

2. Connecting Citizens to Cities

The social behavior expressed by users of the internet is a valuable resource to determine the Collective. This entity, which we refer to as the Collective, is a group of individuals organized around a set of common values that bonds them together. On the basis of a developed model called Interest-based-urbanism, Space&matter defines the positive and negative aspects of developing Architectural models in the age of the Platform Society. Tools to reach out to individuals and collectives enables Space&Matter to interact and closely involve end-users in the early stages of the design process. This Open-Design-Process is developed in a layered set of Degrees of Freedom. Based on Socio-Economic or Socio-Cultural specificities, different approaches can be applied to provide the necessary level of end-user satisfaction. The constant aim is to provide a maximum level of customization while maintaining its affordability. Doing so Space&matter has proven to be capable of designing Residential Open Buildings that contribute to our mission of establishing a more Open City. The strong focus on social inclusion and sustainability has resulted in a diverse cluster of end-users in the collective buildings, which we refer to as Community Buildings. This diversity contributes to a building's Socio-Cultural and Economic Robustness. The diversity and 'Pluralicity' in the buildings program maximizes the building's potential. By increasing, the chance for encounters and the sharing of ideas a Collective housing scheme needs to maintain its Openness. This Openness is crucial for its future existence to prevent the building from isolating itself.

Figure 05: Spheres of influence.

Figure 06: Individual houses around collective court.

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2.1 Specificity and Affordability

For long, architects are dealing with the balance to make architecture affordable as well as local and explicit, to its end users' demands. It was in the beginning of the 20ᵗʰ century that Le Corbusier invented the *Dom-Ino* house, which was a blue print model to effectively provide an affordable solution for the high demand of affordable housing. The combination of *Domus* and Innovation provide an Open and standardized module without walls and partitions. These basic modules could easily be combined and clustered. Perhaps this was the first architectural house designed as an open-system, for residents to complete as they see fit. The *Dom-Ino* functions as a platform, just as well as the Henry Ford Assembly line was an affordable alternative by mass-producing cars. Today most homes on the planet are still built without architects. The radical part of the *Dom-Ino* house is that it is merely the beginning of a process since it needs completion by the residents themselves. It is the abandonment of Total Design (McGuirck, 2014). Stewart Brand has also described this ideal in his book 'How Buildings Learn'. Brand argues that buildings work best when they evolve gradually and incrementally. In todays architecture we see a strong movement that advocates the need for self-empowering systems and not finished houses. Personalization and customization are integral parts of todays society, however customizing the built environment is still lacking behind in this development curve. The different degrees of freedom allow for different levels of interaction with the end-user thus allowing them to customize their built environment and to empower them in a very direct way.

Case study: ObjectONE:

ObjectONE can be best described as the stacking of self-built houses. Future owners choose from three plot sizes; single story with a 2.80 free height, double height plot for houses with a 5.80 height en roof-plots with diagonal roofs for solar panels. The design and infill provide the largest degrees of freedom. Owners can design their own homes by assigning their own architect and eventually the contractor for execution. Besides they have the option to choose from a selection of 'ready-made' designs. Doing so the design is explicit in type, style and budget, but provides certainty from the start. The interiors of these ready-made designs can still be customized in their interior fit-outs.
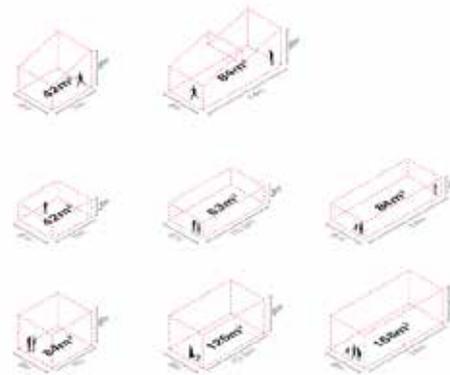
Figure 07: ObjectONE Collective assembly of individual units.

2.2 Interest Based Urbanism

The concept of 'interest-based-urbanism' derives from the notion of the behavior we detect within society. We see a schism between people in their offline living environment, in which they don't know their direct neighbors, with whom they share a corridor and entrance. While at the same time we see a

very strong online social behavior where we're intensely connected to our interest groups, hobby forums or whichever reason to self-organize a smaller group of the like-minded. We develop (online) tools that assist us in making more inclusive and connected environments by proposing a translation of the online behavior into its offline behavior and physical manifestation. In other words; *wouldn't it be possible to start living together with the people with whom you share most interests?* This would allow a residential building to also cater for shared spaces, like sharing a music studio, or a children day-care space.
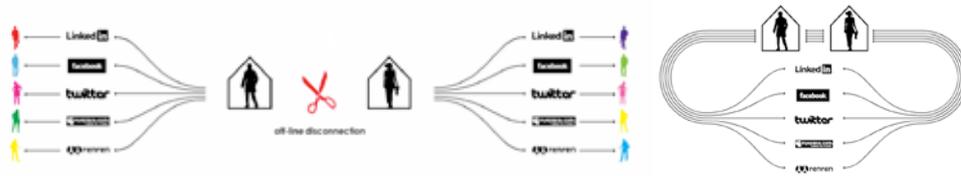
Figure 08: Offline disconnected while online connected

Case Study: CrowdBuilding:

Detecting the fact that individuals are social beings and like to live together; we envisioned CrowdBuilding, where we see that in society people easily flock together on social media and the internet. We see the opposite in the off-line environment. We asked ourselves *'is there a way to make the high level of online connectivity reflect a high level of connectivity in real space?'*. CrowdBuilding is an online platform, which facilitates individuals to express their individual and collective needs. Doing so we see the common denominators between individuals. The functionality of the online platform stimulates to join crowds and to initiate crowds. A crowd defines a collective interest, such as 'gardening, children playground, music studio, etc.' By clustering multiple individuals around a common interest we detect a certain kind of demand. On the basis of this demand a specific supply will be proposed. So we start to make a custom made design, custom towards the collective entity. Doing so, CrowdBuilding kick starts new developments based on prove demand. This method for development initiation is radically changing the process of development & design. Similar to ObjectONE, the cluster of individuals become the crowd-funders for their own living environment. This high level of end-user participation and collaboration results in interesting building typologies and social arrangements. With CrowdBuilding we are adding quality to the program of the building. Where the building itself becomes the facilitator for this inherent program of demands. (www.crowdbuilding.nl)
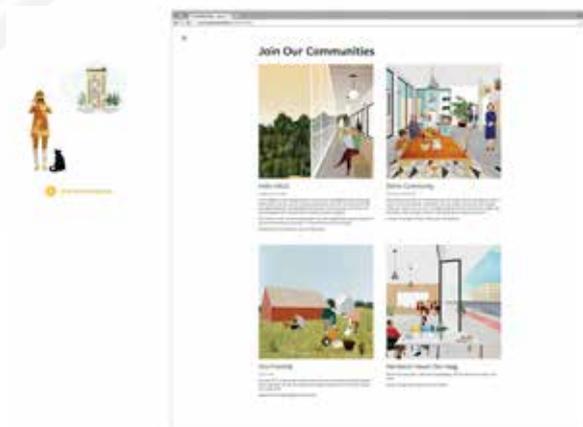
Figure 09: Online platform to facilitate communities.

Figure 10: Sharing facilities with direct neighbors.

3. Conclusion

Providing high quality living environments for affordable budgets is necessary in our urban contexts. By using the power of the Commons and tapping into the self-organizing potential of residents, Space&Matter has proven to be capable of realizing highly customizable architectures. Specificity is about expressing the character of its inhabitants, not as a direct translation but rather as an expression of values and standards. Architecture has the capability to act as a medium for the desired self-realization. Reaching this high level of satisfaction is being enabled by an Open-Process approach in Architectural design. The Empowerment of the end-users is crucial. The level of interaction is instrumental for the outcome. Architectural success is a collective achievement. Architecture is not framed by the definition of Design, which the end state is a product of, but rather a continuous process of negotiation and accumulation, of a collective effort and building upon collective intelligence. Added value is created by establishing a well-functioning software (neighborhood structure) inside the hardware (architecture). Building up social capital and providing strong identities makes unique architectural projects more sustainable and resilient. Creating a city by incorporating 21ˢᵗ century tools and platforms enables space&matter to effectively work closely together with end-users by eliminating unnecessary actors in the development and design process. The outcome gets more valuable while proven to be more affordable.

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[E]motive Architecture: Strategies for a Behaviour-Driven Space Configuration

Viola Cambié; Carlotta Zanoli

Researcher, Lombardini22

violacambie.ea@gmail.com

Abstract

As Architect and Engineer, we used to work with the concept of Space. Struggling to find an exhaustive definition, we risk thinking about it as a framework with the same properties of the object we are going to design. Looking at the Space as an abstract background of the objects that we are going to place in it, we risk to not understand how it plays a cultural and social role in human affairs. The configurations of people can be influenced by, or influence, a configuration of space: therefore, the apparent effect of Architecture on social outcomes seems to pass through the relation of spatial layouts. Movement is by far the dominant form of space use and, following this logic, we can argue how spatial configuration can influence the pattern of movement in space. Generative design processes can be used to define the properties for a space layout that better stimulate a sense of well-being through human behavior monitoring. The potential role of generative design processes finds its maximum expression wherever a certain problem's parameters and interactions bring a level of complexity, much greater than that could be handled by human cognitive processes alone. Generative design integrates artificial intelligence by using search algorithms to achieve high-performing results. However, the emphasis on the 'automated design procedures' should not overshadow the central role of the designer's intellectual capacity, essential for the critical judgement towards the employment of algorithms, the selection of input data parameters as well as the criteria of evaluation. Architects and planners now have the chance to calibrate their designs looking at human comfort and social interaction.

Keywords: Space; Configuration; Interaction; Movement; Monitoring; Data-driven design; Generative design

Perception of Space

As Architect and Engineer, we used to work with the concept of Space. Struggling to find an exhaustive definition, we risk to think about it as a framework with the same properties of the object we are going to design. Space comes to be seen, quite simply, as the general abstract background of the objects that we are going to place in it. However, following this reason we are doomed to not understand how it plays a cultural and social role in human affairs.

The idea of space is usually transcribed as the "use of space" or the "perception of space". In all these common expressions, the concept takes on meaning in relation to human behavior. "Human behavior does not simply happen in space. It has its own spatial form (Bill Hiller)". The human faculties that include our senses, perceptions and personal history are the basis of how people perceive Space.

Configuration and Movement in Space

The way people live within the space, such as encountering, congregating, avoiding, dwelling can lead to specific configurations. The relation between people and space can influence what we consider as attributes of individuals. "Configuration seems to be a concept addressed to the whole of a complex rather than of its parts" (Bill Hiller). Configuration is a set of interdependent relations among elements of a system and, as such, subjects to variations according to the scale of those interactions.

Movement is considerably the dominant form of space use and, following this logic, we can debate how spatial configuration can influence pattern of movement in space. Through its effects on movements, spatial configuration tends naturally to define certain patterns of co-presence and co-awareness amongst the individuals living in and passing through the space. The configuration of people can be influenced by, or influence, a configuration of space: the apparent effect of Architecture on social outcomes seem to pass through the relation of spatial layouts and natural co-presence.

In 1966, the anthropologist Edward Twillich Hall published The Hidden Dimensions, coining the term "proxemics" to describe how both 'man and his environment participate in molding each other'. Proxemics depicts the implicit and explicit experiences of an environment and the physical way people inhabit their sensory worlds.

Architecture is organized and structured in a way that increases one's awareness of his surroundings. In order to positively inform human existence, attention should be paid to human sensory capabilities and social dynamics in order to create contextual environments where the spatial dimensions are evocative of personal, social or public interactions.

Proxemics and Navigation Design

Proxemics is categorize through four categories related to the concept of Distance: *Intimate Distance*: 0 - 0.5 m, mainly for non-verbal communication where only the intimate people like members of the family and friends can enter into; *Personal Distance*: 0.5 - 1.2 m (but varies in different cultures), it is meant for the people who are well known to us; *Social Distance*: 1.2 - 3.7 m related to gatherings with people not particularly well known; *Public Distance*: 3.7 - 7.6 m, where only public interaction is possible and demands louder voice, more formal style of language and reduced speech rate.

Based on these definitions, the architectural theory called an '*Aleatoric Milieu*,' begins with the analysis of human dimensions, and moves to how the awareness of these dimensions is enhanced in the process of moving within the space. Considering a gradation of intimacy and density for occupancy in a designed area, the architects could influence how a person may choose to move from one location to the other. Utilizing light, sound and materials, they lead the decision to walk from point A to point B through a memorable place.

EXTENSIONS OF EDWARD T. HALL'S PROXEMICS

inferred extension

intimate distance | body - 0.5m
personal distance | 0.5m - 1.2m
social distance | 1.2m - 3.7m
public distance | 3.7 - 7.6m

note: extension of proxemics assuming a person is able to rotate 360 degrees

sectional   plan
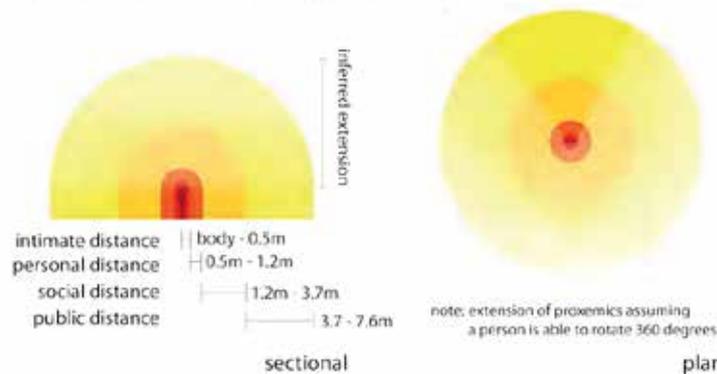
Navigation design is defined as a part of the *Aleatoric Milieu*, where space is configured through narthex, path and node used for wayfinding and creating memory while moving through space. The narthex, an entrance room or space, becomes the decision-making point towards the building navigation. By transitioning from an external public realm towards a greater intimacy, it provides a diminished public scale that informs the users that they are entering a space of lower density if compared to an open street. Therefore, there is a sequence and a hierarchy of proxemic spaces to be

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considered when designing an entrance room that adds clarity to the transition from public to most intimate architectural space. The aisle consists of a regulated set of visual additional information regarding the node. In such a way, the Path consists of a regular pattern of architectural features and activity necessary to prepare the users to reach the Node, considered as the final goal.
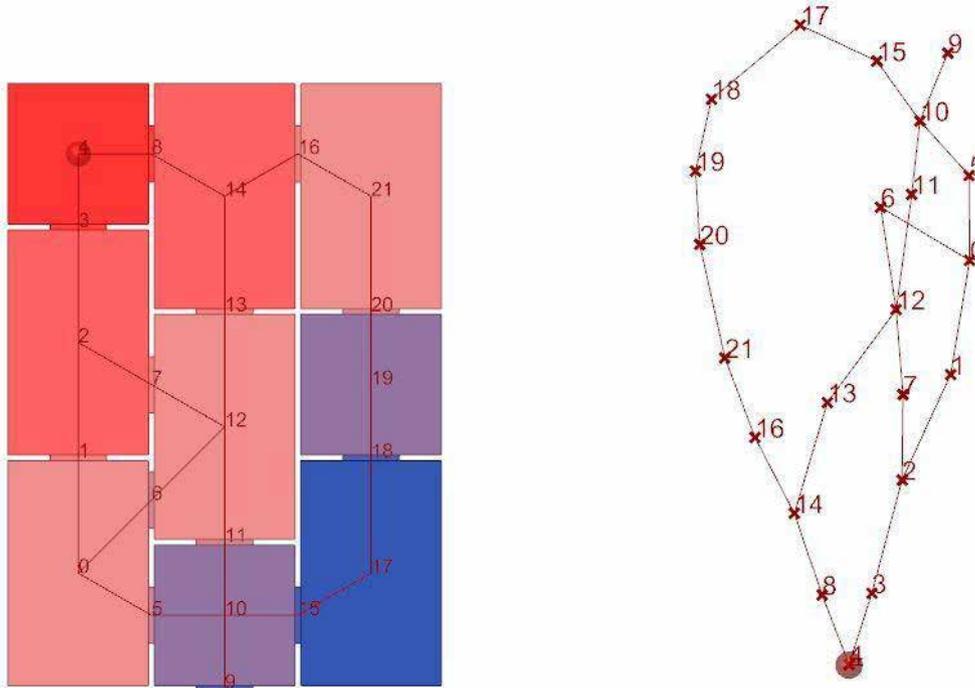
Graph Map examples

Graph Theory

Understanding the way people move through and experience, the space is however, a critical aspect of architectural design since such experiences tend to be subjective and therefore difficult to be simulated by the computer. However, if we look at the problem more closely, we can come up with ways of measuring specific aspects of this experience such as how far people walk between different programs in a space (adjacency), and potential bottlenecks where such movements are concentrated (congestion). These occupant-level metrics give a deeper understanding about the space from the point of view of its occupants and their needs as users. To compute these kinds of metrics we can rely on a branch of mathematics called graph theory, which is based on a data structure called "graph".

A graph is defined by a list of vertices (as such the *nodes* in the *Aleatoric Milieu* theory) which store some properties and a list of edges, which connect sets of two nodes and represent a relationship between them (like the *path* in the *Aleatoric Milieu* theory).

Graph structures are very flexible and can represent many types of relationships. If we represent our spatial information through this system, we can take advantage of many existing algorithms developed for answering specific questions about such structures. For example, if we want to know the length of the shortest path between two points in a space, we can represent all possible paths as a graph of nodes and edges and use *Dijkstra's Algorithm* to efficiently compute the shortest path. In the same way, we can calculate things such as routing, travel distances, adjacency, or clustering through a set of techniques for spatial analysis called Space Syntax.

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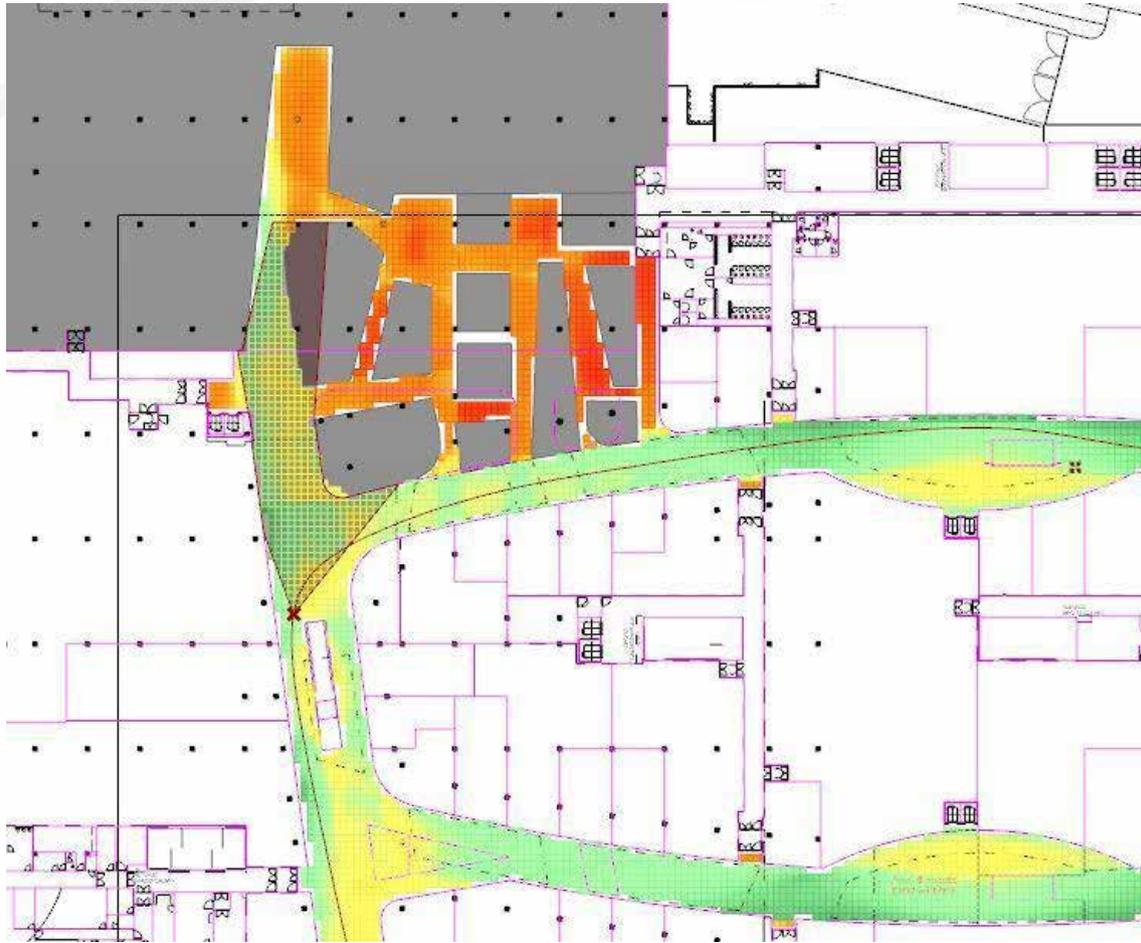
Generative Design for a 'Positive Space'

All these methods provide ways of measuring how a design performs according to complex real-world conditions, generating metrics for a "generative" design process. The practice of generative design can be defined as a computational design process aimed at creating the best possible solution towards specific performance criteria and against given boundary conditions. Generative design integrates artificial intelligence by using search algorithms to achieve high-performing results, such as decreasing the distance between programs in a floor plan (adjacency) or decreasing a potential overcrowded situation due to multiple crossings (congestion), which makes it particularly suited to be conceived as a data-driven design process.

Along with the parametrization of the design space, there are no strict rules about which measures the designer should choose, or how input parameters should be implemented. Generally speaking, the measures should encode as much as possible of what is important to the architect about a design problem, since they will be the only thing guiding the algorithm through its search. If we try to categorize what can be measured about an architectural space, we might come up with three categories:

1. Geometric values, what can be mathematically calculated (such as floor area or height).

2. Quantitative values, what can be quantified through simulation-based procedure, such as structural analysis, fluid dynamics or agent based simulations of crowds. These simulation methods provide ways of measuring how a design performs and can be used to guide an optimization algorithm in order to find the best performing options.

3. Qualitative values, such as personal preference or specific "environmental quality" that influence human beings. Environmental quality is an umbrella term that refers to the sum of the characteristics of a specific environment and how it affects the users of the space.

The ultimate goal of a project for a 'positive space' results in a general idea of space where all these measures, through the public, social, personal and intimate dimensions, converge in the most welcoming and comfortable architecture.

Biophilic Principles

The positive effects that the natural elements have on our psyche have been summarized in the concept of "*biophilia*" (Wilson, 1984), defined as the innate human tendency to experience an affinity or a deep connection with other forms of life and nature.

Biophilic design is viewed as a possible interdisciplinary link to sustainable design. Low-environmental-impact and biophilic design share the same goals such as energy and effective resource usage, sustainable materials and product fabrication, controlled waste generation and disposal, pollution abatement, biodiversity protection and indoor environmental quality.

But how to introduce those principles as a countable measure within an algorithmic process? What is needed for the algorithm to work are numerical values that will be tried out in order to produce various scenarios (*genes*) that will be ranked through "score" (*fitness*). Several researchers have made the effort to translate into measurable scale those qualitative spatial qualities that are generally left to the designers' sensitivity and not properly quantified.

An example worthy of being mentioned is a joint research program between the Laboratory of Affective Ecology, University of Valle d'Aosta, and IRIS - Interdisciplinary Research Institute on Sustainability, University of Turin, which resulted in the creation of an evaluation tool able to quantify the biophilic property of an architectural environment: the Biophilic Quality Index.

The BQI is composed of five sections as follows:

Section 1: The network - the building in the context; Section 2: The individual spaces within the building; Section 3A: Opportunities for visual contact with Nature; Section 3B: If a garden/backyard/terrace/patio is present; Section 4: Non-visual contact with Nature; Section 5: Sustainability.

The BQI allows calculating to what extent a building is biophilic, and it can be used as a rating system where the final score, a percentage value, represents the room of improvement. In the context of a parametric design approach, the challenge is to decipher which design choices can be introduced as numerical variables to be tried out in order to iteratively increase in percentages the final rating BQI score. In the works of Steven Kaplan and Rachel Kaplan (Kaplan and Kaplan, 1989), we can find some examples of such kinds of variables. More specifically, they describe four key words that can be translated into practical design considerations.

Consistency, refers to the degree of concordance and repetition that distinguishes the various aspects of the environment; *legibility*, property that makes the environment easily and effectively explored; *complexity*, defined by the variability of the environment; *mystery*, that indicates the amount of hidden information that may contain a scene and encourage the visitor to explore it.

These qualities affect how we behave inside a space. We need to integrate multi-disciplinary design application in order to add feasible variables into our parametric process, such as:

• Create plans arranged at different heights to enhance complexity.

• Prefer curving edges rather than sharp corners that reduce legibility.

- Use dramatic shade and shadows to improve the mystery experience.

- Optimize the visual access to indoor or outdoor vistas through element orientations.

- Reduce visual barriers to leave sufficient depth.

- Locate stairwells at building perimeter with glass facade and interior glass stairwell walls to form a dual prospect condition.

- Control light levels to generate gradual sense of mystery.

Monitoring, Adjust, Repeat

These considerations are just one piece of the puzzle to creating a vibrant, sustainable, and restorative environment. Monitoring human behavior in public spaces where social activities and community formation are hosted, as well as tracking building performance can be also used to identify the properties for a space layout that better stimulate a sense of well-being.

Monitoring human activities and building performances can be used to inform spatial design where the final shape is not predetermined, but instead constantly redefined. By creating feedback loops between the mapping of human behavior and configuration arrangement, it is possible to explore a variety of consequential design adjustments that can be implemented right away, adapting the final outcomes better towards the intended functionalities.

Human activities and building performances will become the data mining sources for statistical analysis about energy efficiency, positive emotions and spatial layouts optimization. Increasingly sophisticated and accessible monitoring systems will lead the development of new design processes based on retrofitting analysis of large data sets. Tracking the building's performance, assessing sustainability strategies, and making occupants more comfortable will eventually help save money and resources.

The monitoring of people's behavior through CCTV, Wi-Fi connections and mobile devices might have a potential dystopian dimension, but if approached with the necessary safeguards to ensure privacy and data protection, could bring to the next level the architectural and urban design decision making.

Conclusion

Architects and planners now have the chance to calibrate their designs looking at social interaction along with human comfort with a Data-Driven Design approach where information is collected and manipulated to extract knowledge and insight.

The potential role of generative design processes finds its maximum expression wherever a problem's parameters and input values (quantitative and/or qualitative) bring a level of complexity much greater than could be handled by human cognitive processes alone. The emphasis on the 'automated design procedures' should not overshadow the central role of the designer's intellectual capacity. The employment of algorithms, the selection of input data parameters as well as the criteria of evaluation are crucial human prerogatives and fundamentals in the critical judgement of a responsive design process.

''This form of algorithmic or parametric modelling transcends the understanding of the computational paradigm as a mere promoter of complex forms, and contributes to processes capable of forming models that contemplate several parameters involved in the functional, environmental and of the cities and the buildings they contain'' (Lima & Kós, 2014).

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'Pay-as-you-go City': New Forms of Domesticity in a Technological Society

Jeroen van Ameijde[1], Zineb Sentissi[2]

[1]School of Architecture, Chinese University of Hong Kong, Hong Kong, China

[2]Architectural Association School of Architecture, London, United Kingdom

Abstract

Ongoing urbanization, combined with market fundamentalism as the prevailing mode of political management, is leading to the spatial and social segregation of economic classes in cities. The housing market, being driven by economic interests rather than public policy, favors inflexible forms of ownership or tenancy that are increasingly incompatible with the more diverse forms of live-work patterns and family structures occurring in the society.

This paper presents a research-by-design project that explores a speculative future scenario of housing, based on current developments in digital technologies and their impact on the mobility and accessibility to services enjoyed by urban residents. It references technology platforms that underpin the 'sharing economy' or 'gig economy', such as 'pay-as-you-go' car and bike sharing programs or internet and smartphone-based services for taxis or temporary accommodation.

The study explores how new forms of participation in the housing market could circumvent the current segregation of different communities across the city. It describes a speculative system of distributed residential spaces, accessible to all on a 'pay-for-time-used' basis. By offering freedom of choice across domestic functions of greater range and accessibility than found within existing housing or hotel accommodation, the system would enable opportunistic or nomadic forms of living linked to the dynamic spatio-temporal occurrences of social, cultural or economic opportunities. The research references how new forms of social networking create new challenges and opportunities to participate in communities and explores how new technologies, applied to housing, can help to find a 'sense of belonging' within the technological society.

Keywords: Housing; Domestic space; Smart home technologies; Urban planning

1.   Context: Market Driven Housing and Urbanism

Many contemporary cities are planned, managed and experienced as 'developmental cities'; they are governed by policies aimed at the initiation, promotion and delivery of economic growth (Lee, 2016). As the continuous renewal and expansion of cities relies on market speculation, planning regulations and other governmental policies are designed to impose minimal restrictions for private developers and investors. The production of housing, when left to the private sector, is no longer considered part of the fundamental infrastructure of society to deliver social justice but treated as an investment vehicle to store and grow capital. According to Tang (2017), ''economic inequality and social exclusion have intensified enormously with the spread of market fundamentalism and neoliberalism in Western cities over the past decades''.

Market driven urban development amplifies differences in the distribution of wealth across the city, as areas that are more profitable will attract more and higher-value developments. Development and urban renewal lead to the exclusion of lower income groups from many buildings and city spaces, causing spatial and social segregation across cities. As public spaces in the city are increasingly being privatized, to reinforce the interests of commercial centers, gated communities or business districts

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(Low, 2003), the idea of the city of a collective and co-created space is being eroded and Henri Lefebvre's concept of 'the right to the city' no longer applies to the average citizen. Schlosberg (2007) argues that a lack of "broad and authentic public participation" will lead to a lack of both "distributional equity and political recognition", arguing that a lack of equitable spatial distribution of urban infrastructure can contribute to the erosion of political stability and societal progress. Fainstein (2009) argues that many contemporary urban planning practices are ''class biased, undemocratic, inefficient and socially destructive, overemphasizing growth at the expense of other values''.

1.1 Housing as a Structural Element of Society

The planning and organization of housing, either in the private sector or provided by local governments, can be an important mechanism to give structure to society and address inequalities. Since the explosive growth of Western cities caused by the first industrial revolution, Modernist architects have taken on the design of cities as a project. Responding to the slum-like and highly unhygienic conditions in places such as Victorian London, they proposed 'rational' town planning with sunlight access and good ventilation to improve the health and well-being of the general population. The Athens Charter (1933), formulated by Le Corbusier and the Congrès International d'Architecture Moderne (CIAM) promoted the concept of 'The Functional City', in which land planning would be based upon function-based zones for living, working, recreation and circulation. Modern techniques should be used to construct high-rise apartment buildings, with wide in-between spaces reserved for large green parks (Gold, 1998).

According to critics, CIAM's emphasis on universal models for architecture and planning has led to repetitive, monumental and mono-functional urban areas that constrain the development of urban communities. Vanstiphout (2010) has argued that the design of the French suburbs played a key role in the marginalization of its communities and helped cause the 2005 riots in France. He traces the 'social degeneration' of the *banlieues* back to the fundamental misconceptions around the potential of top-down planned architecture to shape human behavior and communities. Other critics proposed alternative models, exploring a more organic approach to the organization of the city. Team 10 was a group of architects who referenced the philosophy of Structuralism and advocated for incorporating concepts such as 'neighborhood', 'cluster' and 'association' rather than separating buildings from each other and from their surroundings. Within architecture, this led to buildings such as the 1960 orphanage in Amsterdam by Aldo van Eyck which features an informal arrangement of living spaces. Van Eyck believed that the breaking down of the orphanage into smaller clusters separated by irregular internal hallways, would allow the young residents to form a bond between each other in a more natural way and allow for the appropriation of the spaces as a domestic environment rather than experiencing the building as an institution (Risselada & Heuvel, 2005).

While Structuralism has been applauded for being a countermovement to the CIAM doctrine of Modernism, there has been criticism about its intentions to support organic urban communities. Söderqvist (2011) points out that many Structuralist projects were designed as permanent and invariant structures, not open to change over time. While many projects incorporate flexible areas open to appropriation by its occupants, it can be argued that decisions about the configuration of residential buildings and environments should be made with input from residents, in order to achieve a more 'democratic' outcome. In his books 'The Architecture Machine' (1970) and 'Soft Architecture Machines' (1975), Nicholas Negroponte pursued the theoretical concepts of computer-aided design processes that allow citizens to be involved in the complex negotiations around urban problems through mediation by 'intelligent machines' or 'design amplifiers'. Similar to the Structuralists, he places a strong emphasis on residents assuming a certain level of agency, offering them the ability to contribute to collective policy through individual actions. The many independent inhabitant activities, forming

a meshwork of interactions and relationships at a larger scale, should inform the materialization and evolution of the built environment over time (Negroponte, 1975). Negroponte's focus on a process-oriented approach to urban planning aimed at facilitating naturally complex processes, following a vision famously advocated by Jane Jacobs. In 'The Death and Life of Great American Cities' published in 1961, it is argued that successful urban areas rely on an ''intricate and close-grained diversity of uses that give each other constant mutual support, both economically and socially'' (Jacobs, 1961, p. 14). Jacobs's perspective challenged the notion that participation and self-organization have no place in the well-functioning contemporary city and that the creation of vibrant, mixed communities should be one of the central aims of city planners.

The short selection of fragments of the historic debate around the organization of housing in urban areas presented here show how there has been a back and forth between philosophies favoring market-driven implementation of housing, and government-led housing development to implement social policies. The conclusion might be that public housing has always resulted in standardized, repetitive urban patterns and that the private sector is best suited to translate the diverse demands of varying people and communities into lively neighborhoods of mixed character and high architectural quality. Yet we know that neither is true, as there are plenty of examples of planned housing estates that facilitate organic and vibrant community life, and there are many instances where private sector led housing development has led to monotonous and low-quality housing.

Our conclusion is that the distinction between top-down or bottom-up organization of housing neither is a black-and-white issue, nor are these approaches mutually exclusive. Future housing projects may benefit from striking a balance between regulation and individual freedoms, so that the interests of the community or urban cluster are safeguarded while at the same time allowing for variation or adaptation. The monopolization of housing markets should be prevented, to promote freedom of choice between housing options and to uphold quality standards. Regulations for minimum space provision, access to daylight and natural ventilation should be enforced to ensure a minimum quality of living for the most vulnerable groups in society (Figures 1 and 2).

Figure 01: Lodging houses in Victorian London, offering the use of a single 'coffin bed' for one night. The same beds would be rented out to others during the day shift. (Photo-circa / The Salvation Army Heritage Centre, 1900).

Figure 02: Subdivided apartments and 'cage homes' are common in Hong Kong, where some of the highest real estate prices in the world force the poorest to live in substandard conditions. Photo-Bryant Cheng / Hong Kong Free Press, 2016).

We argue that within the balance between regulation and self-organization lie further opportunities for architectural and urban designers, understanding housing solutions at a systems level where spatial and organizational aspects are linked to socio-economic characteristics. Public housing, as well as private

sector projects can be stimulated to incorporate more variation and mixing of the types of spaces and activities, contributing to a more varied social mix between lower and higher income people, or people with different occupations, lifestyles or from different family structures or age groups. This mixture could be achieved either through top-down planning and design, or through the incorporation of a certain flexibility for the users to choose how building spaces are used, allowing this to change over time depending on shifting requirements or preferences within the society.

In this article, we explore how we can observe new trends in housing that are conceived at a 'systems level' and extrapolate these into the medium-term in future by connecting these trends to ongoing developments in digital technologies. There are many technological developments in various fields that all affect the way we live, work, and navigate in the city and some are already having a direct impact on our quality of living and on the way we engage in social and leisure activities within our daily lives. The following paragraphs explore some of these societal changes.

1.2 New Technologies for Urban Mobility

The steady increase in functionality and ubiquity of mobile devices, smartphone applications and online services are revolutionizing the way we orient ourselves and navigate around cities. Geolocation sensing in combination with dynamic maps on mobile devices allow urban residents to undertake complex travel routes via public or personal transport, informed in real time by traffic analysis or public transport service updates. The use of public transport has become more convenient in many cities through the integration of electronic payment systems in the form of transport card systems or contactless payment functionality linked to bank or credit cards. Recent developments in mobile phone technologies allow the use of smartphones for electronic payments (such as Apple Pay, Android Pay) or for app-based payment services such as Ali Pay or WeChat Pay in China. The general trend is a move towards a 'cashless society', which may bring many new conveniences and opportunities but may also involve new types of security risks (Yeung, 2017).

In recent years, there have been many developments in the field of urban mobility, such as the new ride-hailing services by companies such as Uber and Lyft. After initially being described as 'ridesharing' companies as part of the sharing economy, there has been widespread criticism around the reduction of workers' rights, disruption of existing taxi markets and increasing of urban congestion. Yet in many locations around the world, the usage of new ride-hailing services is still increasing rapidly, and these forms of mobility platforms seem set to dominate the taxi market in the future. Other technological developments such as self-driving vehicles and Personal Rapid Transport (PRT) demonstrate that car companies are shifting their focus from being a manufacturer to a mobility service provider, as customers are moving away from car ownership to purchasing short-term lease or individual ride services instead.

Ranges of other transportation options have also emerged in cities across the world thanks to online and mobile phone application technologies. Bicycle renting schemes such as Ofo, Mobike, are offering city dwellers the opportunity to travel around the city in a way that promotes sustainability and improves health. While several bicycle companies have experienced strong competition and profitability problems, some have still achieved significant valuation and continue to be funded by powerful backers (Wang, 2018). The systems for renting bicycles use a mobile app and GPS tracking for locating free vehicles nearby a user, app assisted unlocking and charging of usage by the minute. It is a true 'pay-as-you-go' service that is advertised as 'no subscription, no commitment, payment per minute' (Cityscoot, 2019). Similarly, new services have been introduced for renting electric scooters (Figure 3) and cars. Companies such as ZipCar and DriveNow (owned by the BMW group) operate in urban districts through arrangements with local authorities to establish dedicated parking spaces or allow for their vehicles to be parked anywhere including in resident permit zones (Figure 4).
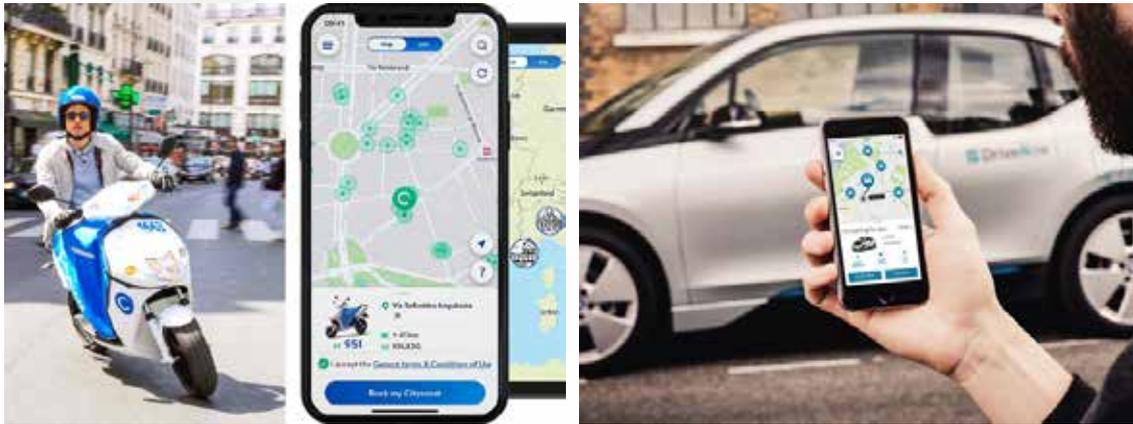
Figure 03: Cityscoot scooter rental platform operating in Paris, Nice, Milan and Rome, using a mobile phone application to locate, unlock and pay for scooter rental fees (Cityscoot.com).

Figure 04: DriveNow was founded as a joint venture between BMW Group and car rental company Sixt but is since 2018 wholly owned by BMW (Drive-now.com).

2. New Technologies for Urban Living

It has been quite some time since travel agencies have been largely replaced by online services that allow to search for hotel accommodation, enriched by an entire eco-system of reviews, scoring and search filtering options that allow for a more democratic and individualistic decision making. Similar to the hotel industry, real-estate agencies are increasingly working with online platforms for housing searches, helping tenants or property buyers to make informed decisions based on detailed neighborhood information that might include school and public transport locations, information on demographics, crime rates, etc. The expansion of many of these web-based platforms into smartphone applications allows users to find information based on their geolocation, enabling them to explore or engage with accommodation stakeholders in real time.

A major impact on the way we use urban housing in recent years is the emergence of online platforms for short-term rental (STR) accommodation, the biggest and most well-known platform being Airbnb. This service offers homeowners the opportunity to market and rent out spare rooms or entire apartments, "revolutionizing the age-old practice of peer-to-peer lodging with a new technology-driven distribution platform" (Guttentag, 2015). Since its founding in 2008, Airbnb has expanded rapidly to such a scale that it has started to impact both the tourism industries as well as the character of entire neighborhoods in certain cities. The platform offers individual homeowners to become 'micro-entrepreneurs' and claims to create benefits for the larger community, such as the generation of tourism-related jobs and other forms of economic stimulus of neighborhoods that were previously not visited by travelers (Fang, Ye & Law, 2016). However, the success of the service has led to undesired gentrification of urban areas, nuisance by tourists and reduced access to housing by ordinary residents (Nieuwland & Melik, 2018). It has been a disruptor of the hotel industry, bringing down pricing for travelers but often due to a reduction of standards. Airbnb is now the focus of major policy reviews in many cities across the world, exploring how to implement constraints to the platform in order to protect the character and socio-economic stability of urban areas and communities.

Airbnb and other temporary accommodation platforms are often regarded as part of the 'sharing economy', as the platforms offer one group of consumers to market their surplus accommodation or services to another group of consumers. Instead of a corporate structure centered on a 'firm' and on 'clients', consumers are part of a networked structure in which they can manage their own value creation. However due to the centralized control of information and fees charged by Airbnb, the term

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'sharing economy' is not entirely applicable and governments may force the company to amend some of its practices. In parallel, the existing hospitality industry is already adapting to the changing demands by travelers, for instance to offer more authentic and localized experiences rather than only sleeping accommodation (Oskam & Boswijk, 2016).

Figure 05 and 06: Total number of Airbnb properties and hotel rooms on offer in Amsterdam from 2010 – 2017. Number of active Airbnb listings in selected major cities worldwide, as of August 2018. (Statista Charts based on AirDNA and Amsterdam Municipality.)

3. New Forms of Living and Working in the Post-Industrial Society

Due to societal changes related to the nature of work, an increasing proportion of working adults no longer work along regular hours or in standard locations. As part of the shift from manufacturing to services industry, flexible and nomadic types of work become a normal thing as the sizes and distributions of company locations get diversified. As early as in the 1970's, Daniel Bell described how in a post-industrial society, knowledge, education and creativity will be the key factors for individuals and institutions to create value (Bell, 1973). As travel and digital communication have become easier and cheaper, the nature of work is shifting from being organized around fixed and hierarchical social structures to more informal or self-organized patterns of activities. In Google offices, employees are free to choose their working hours, seating options and collaborations while self-organized achievements are rewarded. Cities that aim to attract start-up companies and promote entrepreneurialism often create 'innovation districts' that feature flexible buildings for desk-based work complemented by a range of facilities for socializing, networking and life-style support such as restaurants, gyms, etc. The architecture of progress is characterized by 'human-centric' design that stimulates social interaction, spontaneous activities and collaborations, and the flexibility for its users to choose from a diverse range of spaces.

While innovative urban spaces are created to attract people to socialize in the public domain, social media platforms are expanding the ways in which people interact with each other in the digital world. Social media may have initially been set up for informal socializing, leisure and entertainment, but have expanded to incorporate most other types of information and communication-based activities essential to everyday life. The mixing of entertainment, news, shopping, staying in touch with friends, relatives, colleagues have resulted in the mixing and blurring of the previously separate domains of the domestic, work and public space. Through the intertwining of the physical and the digital worlds, the notion of public and private, production and consumption, are no longer separated, as we engage in all types of activities at any time and in any place.

Other important societal changes that characterize the post-industrial society include the diminishing role of traditional institutions such as the church, employer and family in giving structure to people's social and cultural life. Along with secularization of many Western societies, cultural changes have resulted in more 'non-nuclear' families such as single parents, divorcees, unmarried adults, etc. The

housing markets respond to these changes by offering smaller apartments, particularly in urban centers where people might prioritize access to work, services and leisure opportunities over having a generous private domestic space (Figure 7). Non-nuclear family residents have a greater need to engage with social and cultural activities, communities and services in the public domain through which they will be attracted to urban areas that cater to their demands. To be close to good jobs and services, people will move to different districts or even cities, adding to the need to form new social connections in compensation for the lack of family and the familiar.

Figure 07: Micro apartments in Manhattan, New York designed by nArchitects. The building is constructed out of modular, pre-fabricated units ranging in size from 273 to 360 square feet, rented out around $950 a month in 2015, less than half of what is charged for market-rate apartments (Kaysen, 2015). Plan by nArchitects.

Specific new types of housing are emerging in several cities in Europe and the US, responding to the specific demands of single professionals that live nomadic working lives, traveling regularly for work or working for short periods or projects in different cities across the world. While many cities host various types of serviced apartments catering to well-paid 'expats' since many years, new types of hotel and short-term rental accommodations are being built in cities characterized by a dynamic working population. Providing slightly more privacy and space than Japan's capsule hotels, Yotel and Sleepbox are located at airports or urban centers and offer a place to rest for a period of 30 minutes to several hours. Using automated check-in and payment systems, these solutions offer innovative solutions that break with common conventions in the hospitality industry (Figure 8 and 9).

Citizen M is an expanding hotel chain that targets 'mobile' citizens, mostly professionals or tourists who are interested to spend more time in a social environment rather than in private rooms. The hotels feature large lobby areas that combine bar/lounge functions as well as furniture similar to a co-working office, offering hotel guests an environment for flexible activities, people watching or social engagement. The rooms are small but of high quality, allowing the company to charge similar rates as high-end hotels (Figure 10).

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Figure 08: Sleepbox prototype installed at the Sheremetyevo International Airport, Moscow, in 2011. The design is developed for people who need to spend several hours during a transit, but do not want to check into a hotel (Arch group).

Figure 09: Yotel's high-tech cabins feature an electronic bed that can transition into a sofa. Yotel had 14 locations in 2019 in city centers and airports and is expanding to other locations (Yotel.com).
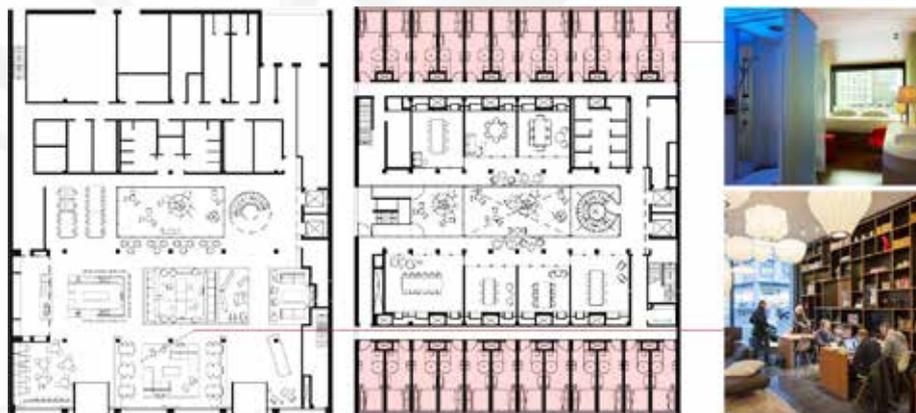
Figure 10: Citizen M hotel in Bankside London opened in 2011. The company offers rooms that are as wide as the bed, but large communal areas that offer breakfast, bar, lounge and co-working facilities (Citizenm.com).

Another recent development in the housing market triggered by changes in live-work patterns and lifestyle preferences is the 'co-living' formula introduced in several cities. Two large properties developed by the company The Collective, in London offer a mixture of serviced apartments and co-living floors that are similar to student dormitories. The co-living floors feature bathrooms shared between two rooms, and a living room and kitchen shared by eight individuals. The company claims to offer 'new typologies of apartments for young people who can no longer afford to rent or buy in the current housing market' (PLP Architecture, 2015). The property in Stratford, London incorporates 250 rooms of which the majority measures 12 square meters, supported by a range of communal facilities including gym, sauna, library, cinema room and roof terraces. The community spaces are located around the building to offer residents different ways to socialize and collaborate, expanding the size and types of domestic space in ways that go beyond the standard conception of urban apartments or public spaces (Figure 11). The properties are being marketed as opportunities to expand professional networks and social circles for young professionals who have recently moved into a new city, playing into the contemporary notion of nomadic young professionals seeking a sense of belonging and a new type of family structure after they have left their home environment (Hurst, 2019).

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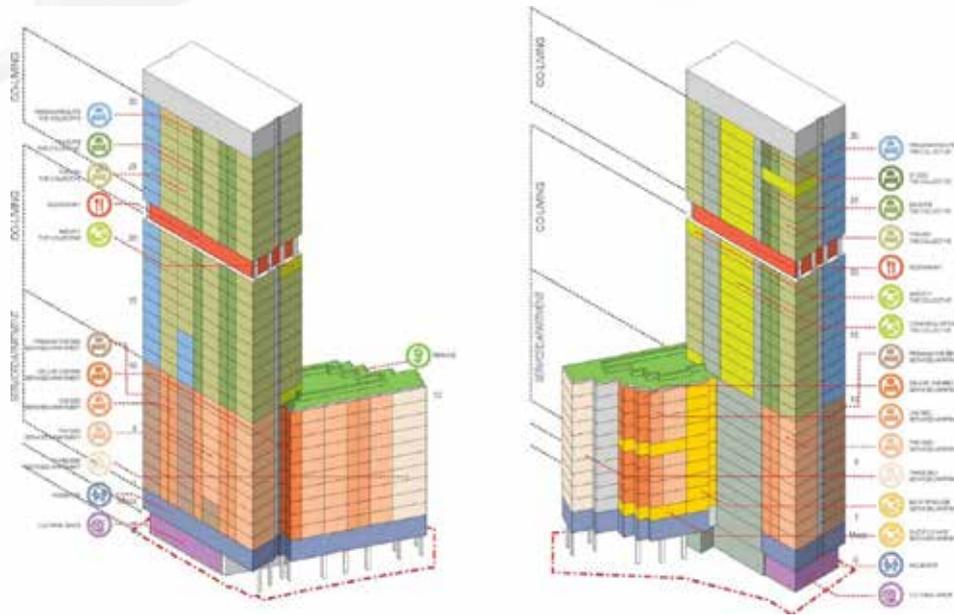
Figure 11: 'The Collective' co-living property in Stratford, London. The lower segment features serviced apartments and the top section co-living floors. A restaurant, roof terraces and other community spaces are distributed around the building (PLP Architecture).

4.   The Extrapolation of Current Trends Towards the Future

This article has outlined a selection of insights around the history and current state of the production of housing, as well as some specific technological developments, that when combined form the basis to speculate on the possible future of domestic spaces in urban centers. After a period of building large scale standardized public housing projects which were largely unsuccessful in creating vibrant neighborhoods, many cities switched to rely on the private sector to respond to diverse and complex housing needs. Market driven housing has produced some innovative solutions but has also led to inequality and social segregation, which may in the long term erode political stability and societal progress. Regulation should be implemented to protect vulnerable groups and stimulate diversity, competition and innovation in the market. Negroponte argued for rule-based systems that allow for agency of inhabitants, giving residents a voice in determining the materialization of the urban fabric.

Many new technologies around online services and mobile phone applications allow new ways to navigate and inhabit the city, searching for transport and short-term accommodation on the go. As we are moving to a cashless and keyless society, several innovative platforms are allowing consumers to participate in the production of value, which leads to more distributed and diverse ways to live and experience the city. This focus on experiences rather than materialism fits a new generation looking for participation, a sense of belonging and personal development.

5.   'Pay-as-you-go' Living

The research and design project presented here explores the extrapolation of trends around market-oriented housing, projecting further diversification, reduction of space allocation for basic needs, and a response to more flexible and efficient use of living spaces throughout time and across cities. Trends towards a culture of experiences, digital archives and fast fashion may lead to less need for storage of personal belongings. As people work irregular hours and on temporary projects in different locations, it may only be a matter of time until more cities start to see capsule hotels similar to Tokyo, in different

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forms as can be seen in Yotel or CitizenM. Compact rooms may be rented on an hourly basis so that every customer pays exactly for their specific use. Thanks to automated reservation processes, there is no standardized check-in or check out time. Additional services such as breakfast or lounge space are paid for through the price of food and beverages, similar to coffee shops that double up as co-working spaces. City policies and planning regulations can be adjusted to let several competing companies operate living pods on a wide range of sites in cities, similar to competing car-sharing services or bicycle schemes. Initially, series of small clusters may start to appear within the city, distributed at regular intervals to ensure there is always one within walking distance (Figure 12).

At first, they are located at small infill sites such as parking lots, unused sidewalk spaces or small urban redevelopment sites. The buildings would be constructed out of prefabricated modular units, which thanks to embedded structural steel frames can be assembled with minimum disruption to the surroundings. Modules are combined with special bolts that would allow them to be easily disconnected, allowing units to be relocated or replaced with other types, depending on shifts in demand. The clusters of modules form buildings which shape is never permanent, their configurations can continuously change over time, informed by the dynamism of the urban context

There would be different levels of luxury offered to customers, evident in the density and arrangement of modules and the levels of privacy that are created. Low cost accommodation is reached without lift access but through stairs and galleries, the units are arranged in low-rise clusters at infill sites within urban centers. Accommodation that is more exclusive is situated at rooftop locations, accessible through a lift and offering panoramic views across the city (Figures 13 and 14).
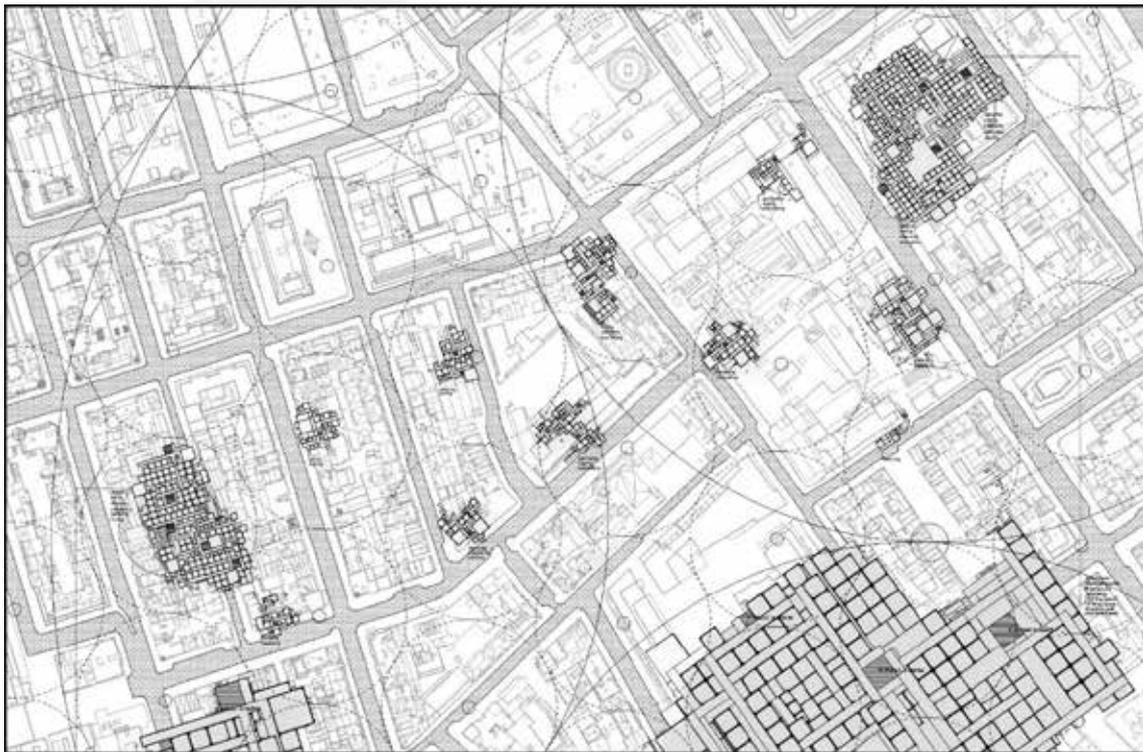
Figure 12: Small, medium and large clusters develop organically at regular intervals across the existing urban fabric of London.

Figure 13-14: Small groups of prefabricated living pods cluster together at infill sites in the city or on accessible rooftop locations, accessible via cost-effective gallery access or via compact lift and stair cores.

Figure 15-16: The different types of cluster organizations offer various types of temporary accommodation at different price levels featuring contrasting levels of views and privacy.

The usage of these domestic facilities would be charged by the minute, adjusted dynamically depending on supply and demand similar to Uber. Customers would use a mobile phone application to search for a specific available unit nearby, pay via a secure digital payment system and receive GPS map-based navigation instructions to their destination. The charges per minute are higher for the first phase of use and are reduced automatically during longer periods of use, to account for cleaning costs and compete with hotels. Users would be able to choose different levels of privacy depending on how much they are willing to spend; the different platforms would incorporate a range of options varying from simple capsules with shared bathroom facilities to luxury compact penthouse rooms (Figures 15 and 16). Following the recent emergence of self-navigating luggage, it can be predicted that clothing and other personal possessions can follow along with the residents; the buildings would be designed to be accessible to these solutions.

6. Separation of Functions

Much of the space in traditional apartments is only used for special occasions and even essential space is only used for a portion of the hours during working days. It would be more cost effective if the activities within domestic space could be separated, and space could be acquired for those activities only when needed. The space around a dinner table for instance could only be rented when guests come over, if most other meals of the week are enjoyed on the sofa. The same dinner table

space could be used by other people on different times of the week, if there is enough accessibility and transparency in the market. Online and mobile technologies allow for fluidity in the connecting of demand to supply, and to monitor and analyze user patterns, which can inform the adaptation and growth of the catalogue of space options and locations over time. In this speculative project, clusters of spaces spread and grow across the city, combining different modules with specialized facilities for various activities (Figure 17). The amounts and ratios of different types of modules in each cluster would depend on the location and demand.

Figure 17: The breaking up of different domestic activities into separate spaces allows users to pick and choose which spaces they need and when, and only pay for the spaces and time used.

7.   New Types of Domesticity

The project presented here aims to provoke questions about the nature of domestic spaces in the city, illustrated through speculative imaginations. Besides the separation of functions in highly privatized spaces, the systems explored here offer an opportunity for the creation of shared spaces in between the pods. Careful arrangement of medium and large-scale clusters would allow for courtyards or

atrium spaces that function as a large 'living room', a new type of collective domestic space that accommodates informal gatherings with friends or spontaneous interactions with fellow nomadic citizens (Figure 18). Similar to the co-living schemes that are currently being introduced in London, this future scenario places an important value on spaces for social engagement, to offer residents a sense of community. Through the arrangement of the modules, in-between spaces can be created in spatial patterns that result in a range of different places with different sizes and levels of privacy, open to appropriation by users in spontaneous and temporary ways similar to the architecture of Aldo van Eyck. Participation in social events is not centralized and forced, but allowed to be self-organized, giving residents the freedom to choose when and how they want to socialize or collaborate. The architecture would promote the emergence of new types of family or community structures that are not fixed or hierarchical but offer affective care to young people that are new to the city or passing through due to the nomadic nature of their work.

Figure 18: Large clusters of domestic activity pods can be arranged around an internal atrium that creates new types of collective domestic space.

8.   Conclusion

By extrapolating and combining current trends in the development of housing and digital technologies, we can speculate how future housing providers might offer more flexible and distributed accommodation services that offer a greater choice to city dwellers, supporting their more dynamic and nomadic lifestyles. By reintegrating compact living accommodation at a range of price levels within the heart of cities, local governments can reverse spatial social segregation, promote cultural exchange and nurture societal progress. Similar to Airbnb, these initiatives could enable local property owners to rent out their parking lots, courtyards or rooftops and instead of displacing original residents accommodation could be added that densifies the city. These systems could encompass more than tourism, as many young people aspire to live close to vibrant urban areas and wish to become residents

in relation to their study or work project necessities. As these projects are temporary or periodic in nature, people may shift their residential location more flexibly without the burden of fixed property ownership or tenancy agreements.

This project aims to raise provocative questions around the nature of the home, and whether people may feel more liberated and productive in strategic locations, removing the necessity for long commutes but involving sacrificing other values. The speculative systems could allow people greater freedoms to choose how and where they want to live in a dynamic fashion, but may involve the loss of a sense of privacy or stability. There are other significant vulnerabilities to these types of systems, as they are susceptible to the reduction of quality standards similar to the lodging practices in London or Hong Kong. Minimum regulation would have to be in place to safeguard standards, accessibility and competition.

The residential spaces presented here may not be attractive to all types of people and will probably be aimed mostly at people in a certain stage of life without children or many physical possessions. The project aims to raise questions about the extent to which city residents value a fixed address to call home, or whether for some people, a new form of 'homelessness' could free up a significant part of their income and allow for other personal freedoms that will stimulate their pursuit of self-actualization.

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BLOOM: Materialising Computational Workflows

Michail Georgiou; Odysseas Georgiou

[ARC] University of Nicosia, SEAMLEXITY,

nfo@hub.com.cy

Abstract

The paper presents ongoing research, aiming towards affordability of complex forms in architecture. The research supports that the above objective can be approached by re-examining and integrating materiality and form-finding techniques in computational feedback models. Within the above framework, a computationally enhanced design process is proposed and presented through a realised case study.

Keywords: form finding, computational design, materiality, gridshell

1. Introduction

The paper presents current developments and outcomes of ongoing research, aiming towards affordability of complex forms in architecture. The research supports that the above objective can be approached by re-examining and integrating materiality and form-finding techniques in computational feedback models. As such, an enhanced design process is proposed and presented, incorporating a series of digital simulations verified by parallel physical testing aiming at feeding a core computational model.

Materiality and computational form finding techniques are presented as design tools enabling major cost reductions as opposed to custom, post-designed solutions. Notions such as "active bending" are integrated through finite element analysis in an attempt to fully assess and exploit the behaviour and nature of the materials used. Such behaviour is computationally simulated and physically verified while it is further enhanced by additional linear elements instrumentalized to optimize structural performance.

This paper expands upon the findings of a case study, the latest (fifth) of a number of prototypes that have been constructed within the framework of the research to investigate affordability of complex forms in architecture. As such it presents a number of developments and shortcomings as follows.

The current prototype, called Bloom, departs from its predecessors (Georgiou et al. 2015) as it belongs to the category of gridshells. As such it is the first prototype that embodies the potential of a non-temporary structure which hasn't been adopted in previous examples. The structure was made out of recyclable UPVC electrical conduit pipes, secured using custom-made rubber and UPVC joints. The gridshell was assembled flat on the ground and was bend in place by a team of eight volunteers without using mechanical means. The form was achieved by instrumentalising the bending forces induced on the pipes using a digitally fabricated formwork as defined by a computational model. The gridshell structure was finally braced using steel wires secured on the gridshell joints.

The design process of Bloom has involved Bending-Active and digital Form-Finding Simulations implemented using Kangaroo for Grasshoper. In parallel the result of the simulations were verified using full 1:10 and partial 1:1 physical models. Finite Elements Analysis using dummy cables was employed to simulate and verify the bending active performance and also to optimise bracing layouts. These simulations have also been verified using a 1:10 and 1:1 scale models. Furthermore, a digital Lift/Assembly simulation was carried out to define the construction workflow. Finally a digitally Fabricated Temporary Formwork has been employed during construction to reach the required shell

geometry. On the other hand, construction logistics was the domain in which substantial shortcomings have been highlighted. The complex requirements of the jointing system, which had to perform on multiple levels, paired with the need for affordability have imposed a narrow field of design solutions. Even though the system functioned as planned, during lifting, assembly and throughout the life of the Pavilion, it has proven extremely labour intensive and time-consuming during construction and installation.

2. The Prototype

The Prototype Structure, named 'Bloom' (figure 1), was a winning entry of the International Open Call: Second Nature part of Pafos 2017 European Cultural Capital Events. The competition called for design proposals on affordable temporary structures to raise cultural awareness and to enrich neglected areas of the city of Pafos. 'Bloom' was among the seven shortlisted entries invited to be constructed at the Municipal Garden of Pafos, Cyprus.

The design consists of a single doubly curved surface, blooming out of central pillar to form a vaulted enclosure with four entrances/openings. The central pillar hosts a bougainvillea plant which is supported by the aforementioned structure. A cantilevering bench made out of twelve individual seating elements, frames the central pillar. The bench is made out of 2.5 mm mild steel sheets, using a waffle substructure and was digitally fabricated using an industrial laser-cutter.

Key constraints that drove the development of the project were cost-effectiveness and assembly efficiency. Additionally, the research team strived to achieve higher levels of structural capacity than previous prototypes without compromising the above strategic goals. Similar to preceding attempts, the characteristics of lightness, elasticity and suppleness have been determinant factors in selecting materials and defining their organizational logic.

As such the research team investigated the possibilities presented by gridshell structures while capitalising on materiality knowledge and construction experiences gained from already completed projects. Consequently the construction of Bloom involved the use of recyclable PVC electrical conduit pipes as a structural system, shaped and secured using custom-made PVC/rubber joints. The pavilion was assembled flat on the ground and was bend-in-place by a team of eight volunteers without using mechanical means. The form was achieved by instrumentalising the bending forces induced on the pipes using a digitally fabricated formwork as defined by a computational model. Finally the gridshell structure was braced using steel wires secured on the above-mentioned joints.

Bloom has a footprint of 39.6 m², a surface area of 74.9 m² and an estimated weight of 200kg. It is the largest pavilion in terms of covered area attempted by the research team at double the size of the largest of its preceding projects. Its structural member's total length stands at 702.4 m and has total cable-wire bracing length of 870m (in double lines). It should be noted that Bloom's structural members, have the smallest diameter, 25mm of all previously erected research pavilions that utilised UPVC pipes as a structural system. On the contrary, it employs the largest amount of structural joints, 1368, as employed by its gridshell logic. The material cost for the pavilion (based on retail material/fixings prices in Cyprus for 2017/2018) presents a noteworthy figure of 50.5 €/m². The pavilion remained standing for a period of 12 months after which it was disassembled according to the contractual obligations. Over this period, it exhibited no signs of fatigue and end-of-life measurements indicated deformations from initial shape of +/- 25mm.

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Figure 01: BLOOM Prototype, Pafos Municipal Garden, Cyprus.

3. Form Finding Techniques

The shape of the pavilion, defined by the site boundaries and constraints was developed using a computational form-finding process. Kangaroo for Grasshopper3d was utilised in order to simulate an inverted funicular structure, withstanding the external loading conditions while adapting to the proposed architectural layout. A parametric model controlling the translation of the supports and boundary conditions was initialised and was linked to the physics simulation modelling, optimising the shape respecting both the usable space dimensions and circulation while maintaining its structural integrity. Forcing the simulated elastic shape to adapt to a hypar-like shell structure meant that Bloom's design was differentiating from previously designed pavilions and their bending-active free-form shapes. The proposed gridshell would therefore utilise both the materiality and the form-found shape in order to achieve a lightweight structural result. In addition to the computational form-finding technics, the design team opted for developing precise and accurate physical mockups aiming at simulating a real-world response of the structure (figure 2). A careful selection of the materials and their structural behaviour was carried out in order to enable simulations of the structural performance using a 1:10 scaled mockup (Addis 2013). The elastic and snapping behaviour of the mockup materials was tested and compared against the proposed UPVC tubes. The scaled model revealed the actual deformation demands of the structure and the required rotational capacity and limits of the gridshell structural members and joints. The above mokups have also presented an initial proof of concept for the proposed on-site assembly strategy of bending the pavilion in shape starting from a flat surface.

Figure 02: Case study, 1:10 Physical Model.

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4.   Simulating Materiality

A great challenge for the project was to integrate the physical behaviour of the materials used and their structural and geometrical characteristics in computational models that enable control over design (Fleischmann and Menges 2011). As such the geometry was guided by such computational models, produced using a core parametric definition in Grasshopper 3D. The models were used throughout the design and construction process, continuously fuelled with information originating from testing parallel physical and digital models from and to which there was a direct transition and flow of information.

Research on materials was conducted early-on and a selection of locally available resources along with the above properties and performance was documented. The behaviour of these materials was embedded in the computational model, while a series of physical tests verified their ability to be manually shaped as digitally predicted and respond to form geometry and structural efficiency. Physical tests were conducted with the different sizes of UPVC tubes in order to identify the elastic behaviour of the material used (Lienhard, Schleicher and Knippers 2011) (figure 3). Simplified analytical expressions (Georgiou et al. 2014) were used to approximate the curved geometry of each member. These equations were initially integrated in the parametric models, enhancing the precision of the aforementioned digital form-finding process, embedding within, material properties and approximate performance characteristics (figure 4).
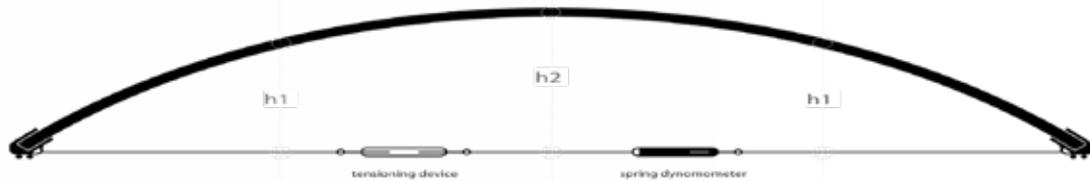
Figure 03: Bending physical test set-up.

Figure 04: Shapes generated using the parametric model incorporating material properties.

Physical experiments defined the actual material stiffness in order for more advanced numerical analysis to be performed. The stress distribution of the structure was investigated by performing numerous analyses, during the numerical model was incrementally deformed (Happold and Liddel 1975). The results of the method were integrated in and compared against the parametric model informing and improving its behaviour. As the shape of the pavilion evolved through digital prototyping and physical testing, its structural capacity was verified at all steps. In order to achieve interoperability between the parametric model and the numerical simulation software, a specialised plugin (Georgiou et al. 2011) was used (figure 5).

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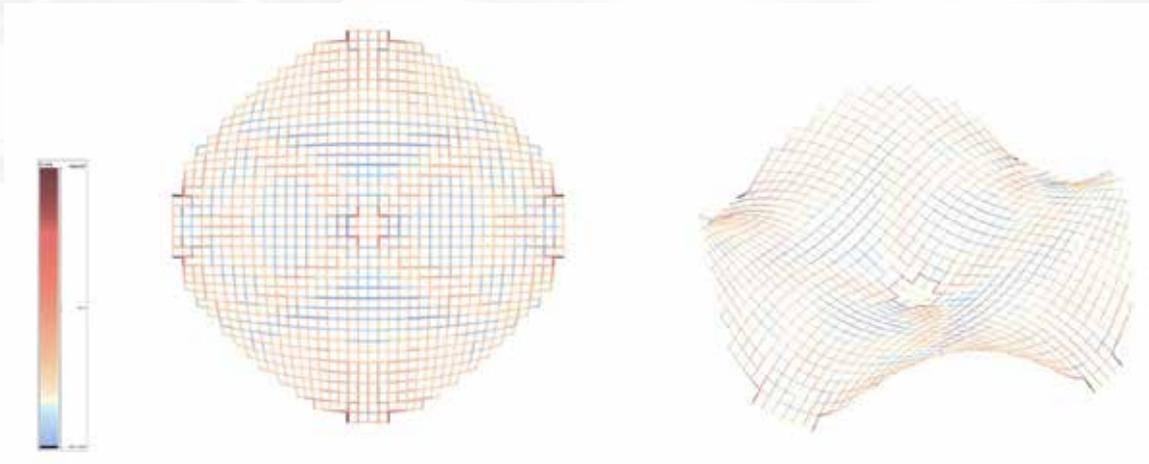
Figure 05: Structural Deformation Analysis.

5.   Construction Assemby and Logistics

On-site assembly processes and construction logistics were determinant factors in achieving the desired degree of complexity while maintaining affordability and constructability.

On-site assembly has been an integral part of Bloom, and all previous prototypes, especially due to the limited construction time imposed by the competition rules. Moreover, assembly strategies proposed by the research team have been deliberately relying on unskilled personnel (students, volunteers and faculty members) promoting the concept of affordability from a workmanship perspective. Facilitating erection and complying with the above constraints was therefore taken on board since the early stages of design. Working with a gridshell structure logic enabled the proposition of a flat surface that could be bend-in shape without using mechanical means or skilled workforce (figure 6). The team reached proof of concept through a series of digital simulations using Kangaroo for Grasshopper 3D which were verified by physical models testing. The same scaled models that have been utilised to test deformation demands of the structure have been employed to test the proposed on-site assembly strategy and the requirements in personnel to achieve bending the pavilion in shape. The desired form was eventually reached by instrumentalising the bending forces induced on the structural members using a digitally fabricated formwork as defined by the computational model. The actual on-site assembly process involved additional temporary scaffolding elements, used to assist lifting the pavilion structure before bending it in place. The scaffolding has also been used to host the digitally fabricated formwork (figure 7). Once in shape, the gridshell structure was braced using steel wires secured on the gridshell joints.

Figure 06: Assembly process, conceptual diagram.

Figure 07: Assembly process, Scaffolding and digitally fabricated formwork.

Designing systems to streamline construction logistics was equally considered early on and different strategies were repeatedly revisited during the design and testing phases.

UPVC pipes were chosen to facilitate construction in terms of simplifying the connectivity of constituent parts. UPVC pipes presented an advantage as their in-build socket enabled the formation of long continuous members that would otherwise be very difficult to source.

While the above strategy effectively reduced the number of possible joints, the gridshell nature of the proposal required a large number of other connectivity solutions between the structural members of the pavilion. As indicated in figure 8, the proposed solutions were reduced to three categories: 48 x Edge Condition Joints (Type A), 68 x Edge Condition Joints (Type B) and 1252 x Cross Joints (Type C). Due to the performance requirements and their increased number, an efficient resolution of Type C joints was essential in meeting the strategic goals of the project (figure 9). Type C joints had to allow sufficient rotation while erecting the pavilion while facilitating bracing connectivity. The team's initial approach was to form pin joints by pre-drilling the structural members. Physical testing proved the approach problematic as the rotational force exerted on the pin fixtures during erection was causing the structural members to fail. As a result, a non-destructive solution of controlling the rotational capacity by means of friction was proposed and adopted. The solution called for rubber sleeves to be installed at every type C and B joints coupled with an innovative tie wrap bond inspired by nautical knots. The tie wrap bond was intentionally left unfastened to allow sufficient rotation during the lifting of the pavilion and was tighten once the pavilion was in shape. While the above solution had successfully resolved type C joint connectivity the issue of attaching and securing the bracing was still unresolved. Finite Element Analysis and testing on the 1:10 physical model proved that reduced bracing could still perform adequately. As a result the design team proposed an optimised bracing layout, at every second type C joint, effectively reducing the amount workload and bracing components to half. Additional elements made out of UPVC were proposed to host the wires of the bracings. These UPVC clips were

designed to saddle on the type C joints and secured using a set of tie wraps. The clips carried a machine screw on which the wire bracing was fastened using common electrical cable connectors. A custom washer was digitally fabricated to facilitate holding and tightening of the wire connector. A digitally fabricated acrylic washer, an abstract representation of the characteristic regional almond blossom, was added to cover and protect all underlying parts of the joint. The total of 636 such flowers provided a unique surprise for the visitor at the interior of the pavilion.

Even though the above described jointing system functioned as planned, during lifting, assembly and throughout the life of the Pavilion, it has proven labour intensive and time-consuming during construction and installation. The multi-component joint that had to be installed at various stages of the construction process, coupled with the large number of such joints significantly increased the design and assembly time of the project. Future work will focus on addressing type C joint disadvantages towards investigating improvements to the aforementioned system.

Figure 08: Type of Joints.

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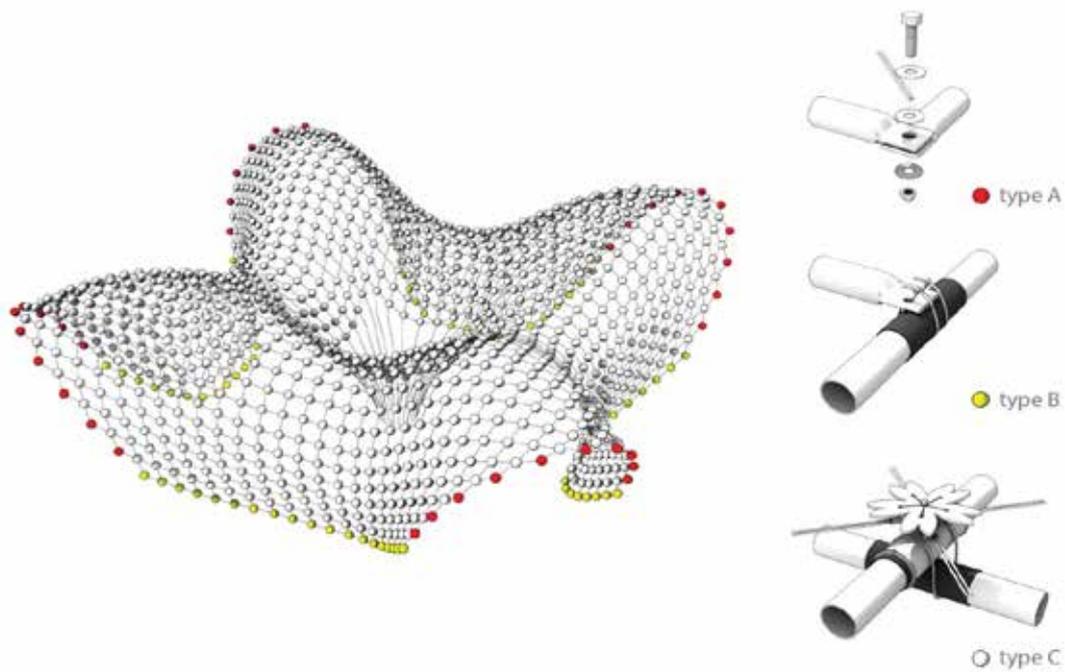
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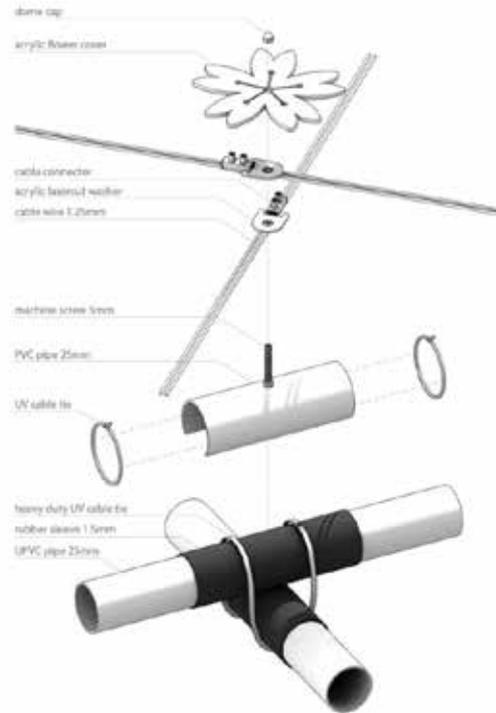
Figure 09: Type C Joints.

6.   Conclusions

The research presented in this paper sets new grounds for affordable complex structures. Bloom was designed and realised under tight constrains and limited resources which provided fertile ground for testing another affordable paradigm.

Within the above framework, it was illustrated that integration of materiality, form-finding techniques in computational feedback models with parallel rationalization and adaptation of construction logistics enables significant savings throughout the design and construction phases of the project in terms of materials, human resources and time.

The design was supported by a central computational model able to form-find and simulate the physical behaviour of the structure. Increased levels of understanding and control over the physical response of the structural members were achieved during the development of Bloom, which maintained adequate structural performance for a period of 12 months, before it was disassembled.

Facilitating on-site assembly was achieved through laying the pavilion flat and shaping it in-situ returning significant reductions in workload and personnel. Simultaneously, streamlining construction logistics at various stages of the design and construction process was attained and illustrated. Adaptation of the joints to respond to assembly and bracing requirements allowed for minimized analytical time and additional efficiency in construction. On the other hand the same flexible and adaptable jointing system imposed increased construction logistics, delaying considerably the assembly process. Future work aims at addressing the above issue.

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The Affective City: Cartography of Machinic Urban Assemblages

Yota Passia; Panagiotis Roupas

NTUA School of Architecture

giotapassia@gmail.com; studioentropia@gmail.com

Abstract

While the city is generally perceived -within complexity theory and dynamic systems theory as a changing field of dense interactions that occur in a range of spatial and temporal scales, we are unable to perceive it or describe it in these terms. The main goal of our work is to redefine space - ontologically and epistemologically- in order to reveal the invisible system of its interactions. Thus, the city is represented via a connectionist model, by means of the representation of the interconnections of its various parts. The project theorizes the city as a multiplicity, a structure of spaces of possibilities while at the same time trying to establish a liaison between the city's properties, tendencies and capacities. While properties are actual and can be observed, tendencies and capacities lie in the virtual level and become actual once exercised. Their intensive cartographies map zones of varying degrees regarding the density and intensity of information that is available pointing them as the city's islands of affordances. In this framework, Hecate becomes the city's virtual map, an interactive mechanism able to decipher, map and connect the superimposed layers of significance informing the city's layout and behavior, in real time. Visualized as a network of richly interconnected nodes of varying intensities, each representing information flows between the system and the city, Hecate is introduced as a visual thinking tool to perceive them in real time.

Keywords: Connectionist Model; Urban Superscape; Affects; Intensity; System

1. Introduction

While space is generally perceived as a changing field of dense interactions that occur in multiple spatiotemporal scales, we are unable to perceive or describe it in these terms while at the same time we are unable to respond adequately to urban transformation patterns. The project theorizes urban space as a complex fabric of forces between relations and aims at redefining space in order to reveal the invisible system of its interactions. The above challenges are being approached through Hecate, a mechanism that is gathering significant information about the city while establishing for them a means of communication. **Hecate is a virtual map and an urban infrastructural system**. As a virtual map, it poses a methodology and a visual thinking tool that pushes the limits of our minds' cognitive capacities to better perceive and visualize space's intricate complexity. As an infrastructural system, it is an interactive city scape that functions as the city's nervous system. It is visualized as a network of richly interconnected nodes of varying intensities, each representing information flows between the system and the city. Hecate is itself a new map of the territory, in constant flux.

Acknowledging the limitations of our cognitive capacities to perceive the complexity of space we turn to cartography in order to extend our minds' consciousness regarding the city while at the same time expanding the city's consciousness regarding its possible futures. In this framework, the research aims at the construction of **a virtual map**, a mechanism capable of grasping a rich variety of possible urban configurations. Through this virtual map, we are able to both enhance our cognitive capacities via a new digital aesthetic (or aesthesis) and at the same time unlock potentialities latent in the urban environment. The virtual map both **as a methodology and a visual thinking tool** is a means to better understand and visualize space's intricate complexity as it unfolds at different spaces, speeds and rhythms.

The mechanism we propose is **the structure of spaces of possibilities** within the city, as we seek to establish the difference between properties on the one hand and tendencies and capacities on the other. According to DeLanda (2013) their basic difference is that while the former are actual the latter have not yet been exercised and thus remain in the virtual. As they both define objective entities - here space and the city - equally and in order to gain knowledge about those entities, DeLanda (2013) proposes that one should create representations of them based on their properties, while performing interventions on them in order to force them to manifest their tendencies. In addition, one should get them to interact with other entities so that they exhibit the variety of their capacities. By superimposing the city's properties, tendencies and capacities a virtual map is produced as a means to map space in terms of both how space is now (actuality) and how space has the capacity to be (virtuality).

As the virtual map is retrieving information regarding urban space and its possibilities, we draw on specific theoretical standpoints in order to more thoroughly define them. Here, we consider the limit of urban space as the limit of its **affordances** or **action possibilities** and not the limit of its form. Gibson (1986) notes that *"the affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. The verb to afford is found in the dictionary, but the noun affordance is not. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment [...]."* As invariant combination of variables, affordances are meant to be objective, real and physical, unlike values which are subjective, phenomenal, and mental. As the term 'capacity' is closely related to the term 'affordance' according to Gibson (1986), it is difficult to find a better example of a concept that shifts the focus from the extensive space of properties to the intensive matrix of capacities. That said we can now move from the static extensive space to the more dynamic intensive one while grasping the variables that explain their intricate correlations.

Theorizing contemporary urban substance on a flat ontology plateau, we are allowed to pull apart its elements so that they are free to reassemble and therefore capable to produce new spatial configurations. Elements can now be related freely as long as they do not fuse together, are not engulfed by other elements or attached to an a priori constructed top-down hierarchy. As DeLanda (2013) notes *"While an ontology based on the relations between general types and particular instances is hierarchical each level representing a different ontological category (organism, species, genera), an approach in terms of interacting parts and emergent wholes leads to a flat ontology, one made exclusively of unique, singular individuals, differing in spatiotemporal scale but not in ontological status".* In theorizing urban space as a palimpsest of properties, tendencies and capacities, we are trying to establish the **flat ontology** of its spatial elements, in terms of interacting parts and emergent wholes. As dualities and their respective boundaries become obsolete, the built and unbuilt, the organic and inorganic are reevaluated in terms of their capacity to affect and be affected, while constantly entering into new urban configurations or assemblages.

We focus on **spatial assemblages** within urban city areas, as we believe that their latent potentialities tend to define their degree of resilience and vitality. Spatial elements such as ground, envelope, internal or external space are mapped in terms of their properties, capacities and tendencies and superimposed on the same **immanent plane** (Deleuze & Guattari, 1987) where they are able to relate to one another freely. On this plane, they are allowed to interact - empathize with one another - rather than stick to their materialistic autonomy. We consider them as **free radicals**, ready to enter to the formation of new assemblages. Instead of mapping buildings or building typologies, we map the **relations** between them and their respective parts in order to enhance the multivalent properties of inhabiting within contemporary urban assemblages.

2. Hecate: the city's virtual map

Drawing from Greek mythology, Hecate (/ˈhɛkətiː/; Ancient Greek: Ἑκάτη, Hekátē) has been the goddess that held the **skeleton-key to all three possible worlds** (of the living, the dead and the

gods). She is also the means through which all traces of information - past, present and future - resurface and associate anew, topologically interconnecting different levels and scales in real time. Hecate then becomes in this context the city's **virtual map** aiming at gathering **information** about the city that is significant while at the same time and most importantly establishing for them **a means of communication and exchange.**

The communication system proposed - draws form from Quentin Meillassoux's concept of contingency (Meillassoux, 2012) - of both machine and labor, is one that transcribes **the contingent city** (its tendencies and capacities) **to the sensible city** (its properties), thus granting us further access to the former. As Meillassoux argues there is a **qualitative leap** from one equilibrium state of a system to another, and therefore we cannot explain one state in terms of the physical laws of the other. In this manner, we can assume that our world is contingent, and in order to better grasp it, we need to focus not on what currently exists, but as Meillassoux puts it, on the **'perhaps'**. (Meillassoux, 2012). These possible states are deriving from the current configuration, while at the same time have the ability to merge with it and reveal more properties than was there before. According to Meillassoux (2012) one could identify the latent potentialities by recognizing what is currently lacking in the current configuration.

Hecate is a registering mechanism of both actual and virtual **networks of significance** within the city as they develop and advance in time. Following the reconstruction of Deleuze's world and specifically his **theory of sense** (developed in The Logic of Sense) by Manuel Delanda, he mentions that Deleuze "clearly distinguishes "sense"' from "signification" (the semantic content of words or sentences), *"sense"* being more connected with *"signification"* (the capacity of words or actions to make a difference)" (DeLanda, 2014) In this framework, the concepts of **significance and difference** are central in understanding the characteristics and behavior of Hecate, each intensive mapping having the capacity to differ in space and time resulting in **a virtual map in flux**.

Hecate maps all affordances of spatial elements within the cityscape, as they change and reorganize themselves into new assemblages. Each intensive cartography monitors one of the city's intensity zones as it is being defined by critical points of change. Hecate is an affective **virtual map** constantly adjusting to the city's networks as they develop into **spatiotemporal data structures** with the ability to store information regarding the city and use it to develop or adjust in the future. These structures are not simply formal objects or outcomes of mapping processes where data enter the virtual map; they are indicative of our computational culture and its aesthetic resonance.
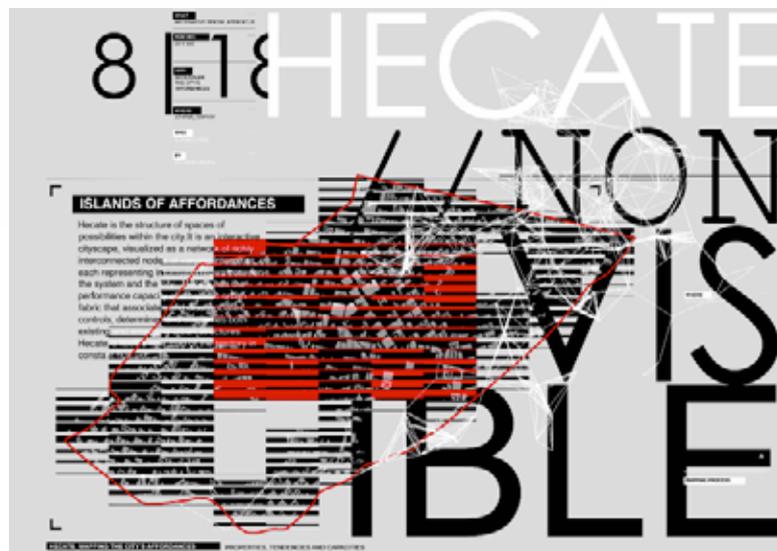
Picture 01: Virtual Map of Athens (Passia Y. & Roupas, 2018).

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In the case study presented, a **virtual map of Athens** (pic.01) is constructed to reflect on the materiality of data and their variations through the representation of spatial relations amongst urban elements. Properties of architecture and the city on one hand and their tendencies and capacities on the other are equally mapped, documented and communicated anew. The topological relations of space tend to supersede the geometrical matrix of built spaces by adding more information to fixed points in space, establishing the virtual map where all points are interconnected in real time.

3. Abstraction

"The task of abstraction in this scenario is to liberate the virtual subject - the designated force of thought - from the trap of the material. But this liberation is conducted precisely by utilizing the resources of the material, with the aid of tendencies, properties and parameters, that determine and govern the behavior of the material system and, correspondingly, constrain the dynamic of thought, forcing it to revise its formation and to triangulate new affordances for conception and action (Reza Negarestani, 2014). Using generative algorithmic processes, we seek to construct **an abstract ontogenic model** that visualizes spatial correlations via a set of translating protocols where any information of the urban environment is transformed into **a map of qualitative tensions**. One of the major research goals is to develop an insight or knowledge regarding the complexity of underlying correlations affecting cities. A constructed landscape of formal elements - as we understand contemporary cities - is built upon perceptions that are restricting. To question preconceptions regarding the city's built reality, Hecate seeks to allow for the experience of those non-visible, non-discrete elements that define the city's identity and material reality. Via a plethora of **intensive mappings** within the urban context, we establish a **methodology** able to visualize the city's hidden properties, tendencies and capacities that have been out of sight and thus misperceived.
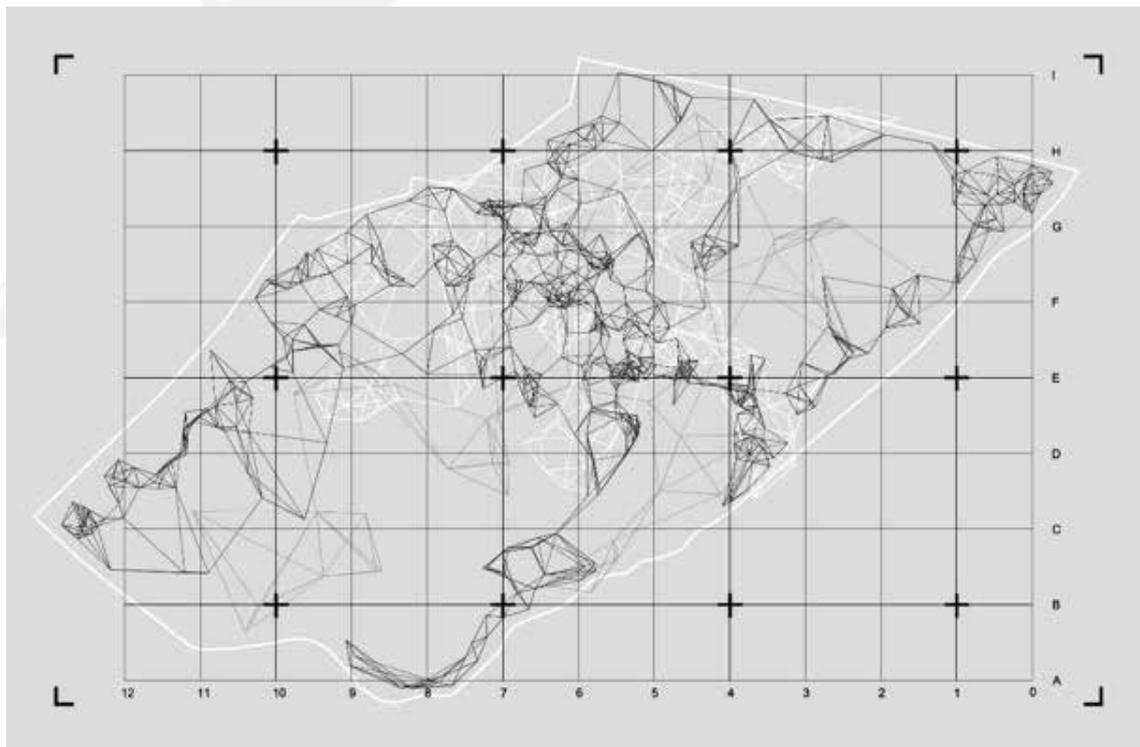
Picture 02: Information Density + Intensity maps (Passia & Roupas, 2018).

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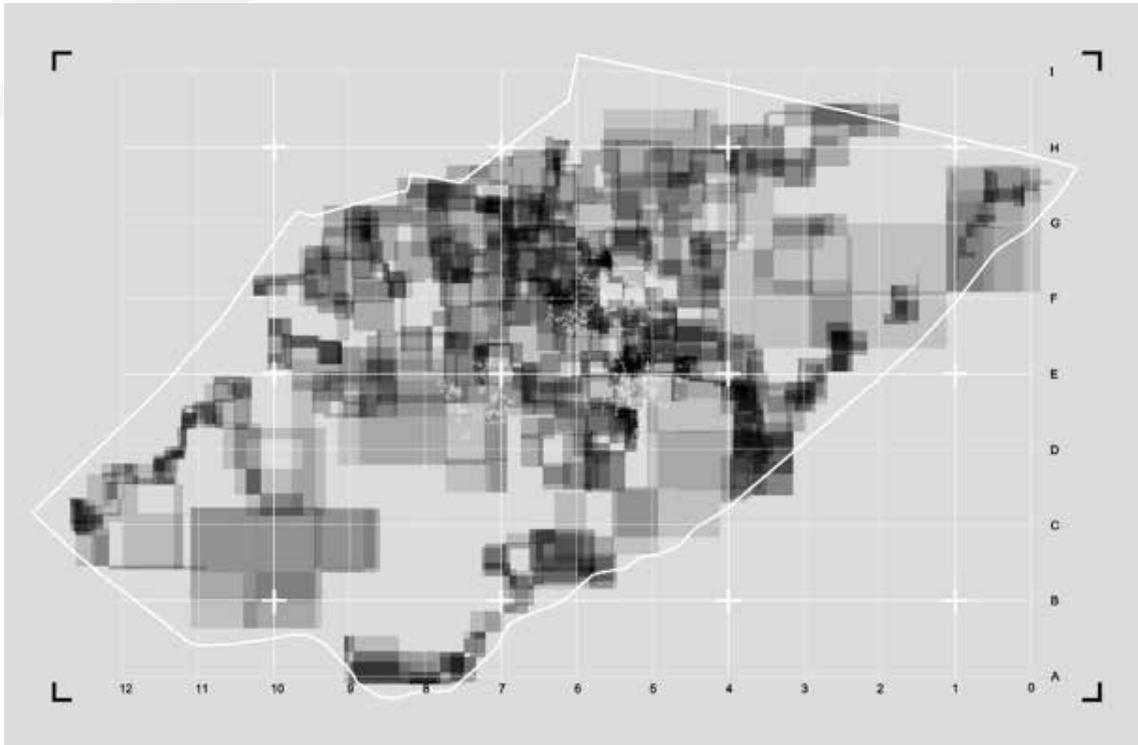
Picture 03: Islands of Affordances (Passia & Roupas, 2018).

The complexity of information within the cityscape hinders our acquisition of cognition and knowledge. As information mapped is both highly differentiated and fragmented but also occurring at different levels, scales and speeds, Hecate actively reorganizes it by applying a set of translation protocols. To that end, each **layer of significance** regarding the city is being translated into geo-referenced information fields (pic.02) based on the number of points populating a specific area and the proximity of these points. The layers' superimposition allows for their varying intensities and densities to emerge (pic. 03), and while the complexity of information remains high, the mappings' representational efficacy allows for the receiver to better perceive and connect with the available information. As new layers of significance enter the virtual map, urban constellations change and adapt informing their structures and information flows between the system and the city.

The mapping methodology proposes that viewing of an object becomes possible from within the object and not only from an exterior viewpoint. By mapping a landscape of interacting points, we have developed a mechanism that extracts information from contemporary urban landscapes without theorizing a single viewpoint as a vantage point. Any geolocated point within the urban sphere becomes then a vantage point of the same value independently of our preconceived symbolic structures. The city ceases to have its own - a priori - coordinate system (the roads or the built structures) and acquires a new one based on its interaction with the receiver. An open system in the process of formation.

This abstraction process aims at complementing the site specific content of significance by qualitatively compressing the available information. The concept of abstraction as a site specific operation is crucial because of its immanent capacity to compress different informational layers in a single entity while at the same time preserving their invariant traits and hence their capacity to diversify into local instantiations. Hecate is in that respect a method for organizing available information, simplifying its representation in a way that it can be perceived or explained, finally diversifying thinking processes and increasing possibilities for new territories of spatial interaction to emerge. After the end of this process, Hecate visualizes **space as a connectionist model**, by means of the representation of the

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interconnections of its parts but without any of its parts. Space is thus differentially defined as being composed of **relational fields** - both actual and virtual ones - as well as by their interactions. In that light, Hecate is introduced as a **cognitive mechanism for the virtual and actual city.**

4. Hecate: an Infrastructural System

Each time, an instantiation of **an autonomous architectural object** is extracted and then reinserted into the city thus creating a new materialized informational network. This network points to areas within the urban context that are highly significant, places where intensities and densities of information merge and overlap. Hecate's physical model is a direct result of those interactions within the global information system of the city. Continuously performing a recurring process of collecting information and re-distributing it in the city, it creates a virtual network of nodes that interact and behave as a "living" organism attached to the actual city. Hecate manifests itself as both an analog and digital suspended framework that sketches out an entirely new map of the territory, a continuous, undetermined and homogeneous network, affording the city the promise of unlimited communication and social interaction.
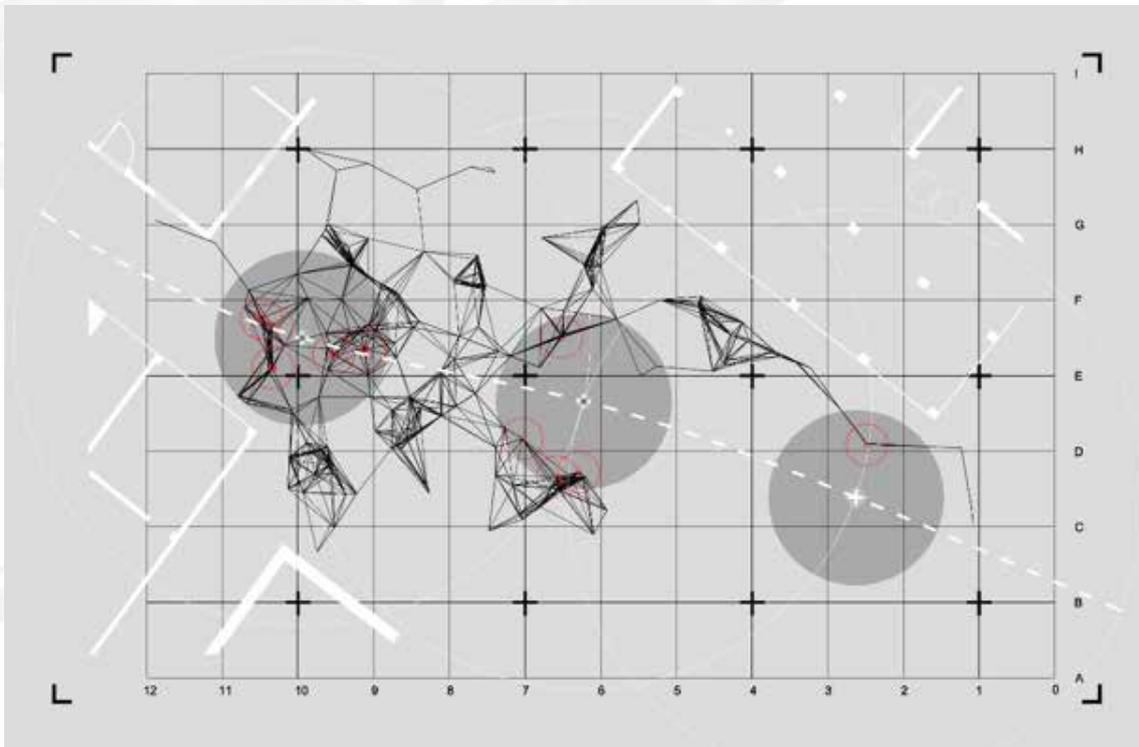
Picture 04: Physical instantiations (Passia & Roupas, 2018).

Hecate is digitally and physically realized as an **interactive connectionist city scape** (pic.05), a connectionist model, with synapses of varying strength, representing the amount of information incorporated as active system passageways. This informative spatial object consists of a network of interconnected nodes, which retain their ability to change according to local information. They are also able to interconnect with other nodes, self-reproduce themselves or withdraw from the system completely, revealing their immanent capacity for life. Hecate's organizational structure has the performance capacity of an elastic urban fabric that associates, disassociates, controls, determines, consumes existing structures within the city.

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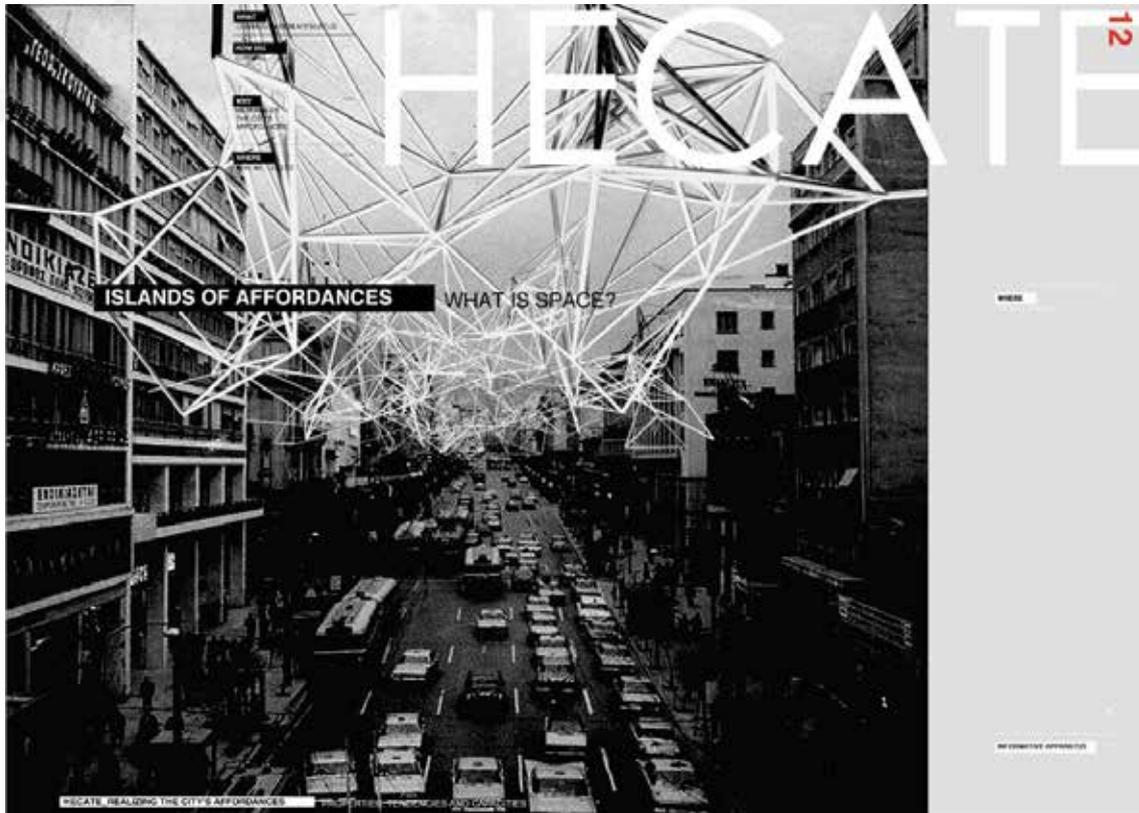
Picture 05: Hecate: Interaction protocol (Passia & Roupas, 2018).

Hecate is composed of four parts that connect the physical and digital realms to further enhance Hecate's impact as a visual thinking tool. It is composed of **a database**, an array of **sensors** attached to the city's built structures, a large number of **AR units** located in the city, and a small number of **physical models** of Hecate's structure. In this respect, Hecate can be experienced within the cityscape both digitally and physically, through the augmented reality units and Hecate's physical models, respectively. A large number of augmented reality units are scattered in specific areas of the city that facilitate the depiction of the available in situ information and enhance Hecate's implementation into the cityscape. Hecate's material manifestation consists of a small number of physical models in human scale where one may experience the space produced through Hecate's net-like structure.

At this point, Hecate is no longer regarded as an exteriority to the city, but as a constitutive element of contemporary urban complexity. As it monitors the city's networks of significance in time, it infiltrates the cityscape to become its most intricate **infrastructural system,** one that merges with its extensive structures to visualize the city's reality. Within the contemporary social and spatial complexity there is no specific vantage point from where one is able to perceive the networks of information within the global milieu. Hecate intervenes at that exact point as an active, interactive networked landscape with both a physical and virtual form, as a space within which one is able to grasp the complexity of the city in terms of networked information fields. Hecate mediates a dynamic, interactive relationship between space and society: an integral part of their complexity coming into being, of **a local and at the same time a global ecosystem of relations**.

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Robotic Fabrication as Catalysts for Emergent Topologies and Traditions: Nomadic Small Pavilions and Permanent Mega Structures in Kuwait

Hussain Dashti

Kuwait University

Abstract

This paper reviews tendencies and drives for future parametric computational design and robotic fabrication/construction automation. It sheds light on the local current impact of the computational paradigm and mass-customized robotic fabrication in Kuwait. This paper is intended to answer the following two questions: Is parametric design and robotic fabrication allowing for emergent architectural topologies? Is robotic fabrication a catalyst for legitimizing change in architectural traditions at a local level?

This has been experimented on two building scales. One with more ephemeral or transient nomadic pavilions, designed by the author, intended to demand our momentary attention, offering essential opportunities for research, experimentation, heuristic testing and prototyping – public delight and exposure. Though impermanent, these can even go so far as to be catalysts for positive change displaying affirmative qualities of temporal architecture.

On the other hand, the author shares parametric design and robotic fabrication practices/consultation on local permanent mega structures currently under construction. Such mega buildings act as proof that geometrically complex buildings do not stay in the realm of small experimental and heuristic research only, but incorporated in large-scale complex building, branding and placing countries on the global map.

Robotic fabrication and construction gives rise to new paradigms such as "zero-tolerance" building with "file-to-factory" production allowing for Ruskinian tectonics blending structures with ornamental aesthetics, similar to gothic architecture. With the profusion of robotic fabrication and construction, the author claims that change in the physical built environment is eminent. A final inquiry will be raised as a future research topic pertaining to robotic in-situ "mobility-on-demand", Artificial Intelligence, "Machine Learning", "Big Data" and "evolutionary robotics" which raises the question of what will our future mass-customized cities look like and what type of physical infrastructure is needed to facilitate mobile robotic fabrication and construction.

Keywords: Robotic fabrication; Mega structures; Nomad; Monad; Pavilion

Introduction

From a sustainable perspective, mass-production and consumption can produce a serious problem of natural resource deterioration. Until a short while ago, the objectives of architectural practices were, concentrating on the functional, structural, and aesthetic, (Utilitas, Firmitas, Venustas) character of architecture. More recently, we are concerned about efficiency and reasonably sustainable and harmoniously integrated in the indigenous environment.

During the eighteenth Century, Europeans philosophers attempted to tackle the question of Knowledge. There were two predominant counter arguments, on one hand, the rationalist trend, supported by

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Descartes and Spinoza, which stressed upon the manner of conceiving knowledge, where reason comes before experience strengthening the innate nature of things. On the other hand, empiricism, adopted by Hume and Locke, which supports knowledge with testimony of senses and experience. Empirical ways of seeking knowledge has been widely utilized in modernism based more on methods, experimentation has been consolidated, and the door has been opened to new digital technologies, and computational processes. Therefore, some concepts started to make sense such as emergence, complexity, and self-organization, which explain fundamental behavior and phenomena for contemporary science.

Digital computational technologies are currently ubiquitous and are definitely being utilized on our buildings and the analysis of our cities. For the last 20 years, the profound impact of computer-aided techniques on architecture has been well charted. From the use of standard drafting packages to the more Avant-guard heuristic use of generative design tools and parametric modelling, digital technologies have come to play a major role in emergent building topologies and city layout helping architects to work both on buildings and urban scales changing the way in which we perceive, design, and build our structures based on unprecedented construction methods and techniques.

Emergent Technology

The emergent technologies and Design, develop skills, and help in pursuing knowledge in architectural design science that is located in new production paradigms. It continues to investigate new synergies of architecture and ecology through the critical intersection of computational design and digital fabrication; projects and products pursued by multiple iterations through hypothesis, material and computational experimentation, robotic fabrication, and evaluation. It involves experimenting with numeric data that makes good description of behavior, morphology, and material properties, that can cover numerous fields of design concentration including materials systems, advanced fabrication, natural and ecological systems design, algorithmic design of urban systems that can be embedded in algorithmic spatial models for culture, climate, economy, and ecology. Rapid production of Alternative are produced through measuring, quantifying, analyzing, and returned as input in the next generative series.

The tangible has caught up with the intangible, and possibilities that were entirely speculative in non-physical domains just a few years ago are now being materialized and built. The term 'digital' no longer only conjures up notions of complex representation, computational geometries and intelligent systems, but also fabrication, craft and materials. At the same time, designers are faced with (and connected to) more tools to make their work than ever before, each packing extraordinary power, accuracy, capability and provocation. Subsequently, the scope on how these tools influence, validate or facilitate the designer is expanding rapidly and the challenge is to navigate such dynamic circumstances with a clear sense of critique on how they assist in advancing architecture as a visionary practice and subject.

Emergence

Emergence is a classical concept in systems theory, where it denotes the principle that the global properties defining higher order systems or "wholes" (e.g. boundaries, organization, control ...) can in general not be reduced to the properties of the lower order subsystems or "parts". Such irreducible properties are referred to as 'emergent.' Until now there is no satisfactory theory explaining what characterizes emergent properties

or what are the conditions for their existence. In this paper, I argue that computational design and robotic fabrication is allowing for emergent design processes and architecture cultures as catalysts for emergent architecture design culture as well as emergent physical topologies. During the last decades, we started observing new architectural typologies that are otherwise unachievable with conventional, non-computational and Non-robotized fabrication, which may include dynamic and spontaneous self-organizing emergent designs based on complex-related parameters. The spontaneous creation of

an "organized whole" out of a "disordered" collection of interacting parts, as witnessed in self-organizing systems in physics, chemistry, biology, sociology ..., is a basic part of either simple or a more complex hierarchy of dynamic emergence (Haken 2014). This self-organizing emergence could be simultaneously hierarchical, characterized at two level structures: the "Microscopic" level, where elements interact, and the "macroscopic" level, where these interactions lead to global patterns varying in the level of complexity. If we wish to understand the architecture of such complexity, we will need a more general, integrating theory of emergence and self-organization. Rapid production of Alternatives are produced through measuring, quantifying, analyzing, and returned as input in the next generative series producing numerous derivatives and iterations that can be file-to-factoried to digital fabrication robots. This digital design/fabrication process is emerging into a new set of design culture, process, production protocols, and professional rolls, allowing architects to be involved in the 'making' production process, reducing the conventional role of the contractor.

High Definition Zero Tolerance

As an academic of architecture with interest in computational design and digital fabrication, I attempt to anticipate the natural proclivity and to look forward on how fecund new developments in technology might prove to architecture. Through design/build experimentation, I attempt to establish a deeper and sustained interest in fabrication focusing on computational design, digital fabrication, verification technologies, 3D scanning and its associated interface with modelling and manufacture.

Cutting edge technology is permitting high-definition zero-tolerance building with high degree of freedom in design pushing for mass-customized production processes. (Castles, 2014) This represents a significant paradigm shift in the area of design and fabrication process adopted both in academia through design pedagogy as well as in architectural practice. This paper focuses on the meaning of tolerance across conditions of fine-grain information, predominantly from a design perspective, but there is also the sense that we need to remain attentive of the opportunities that might be afforded, or lost, across practice and within the construction industry, as Helen Castle 2014, in her editorial for Architectural Design issue "High-Definition and Zero Tolerance" stated.

She provides a holistic introduction on the work of Achem Mengez and Bob Sheil at the AA (1982), using innovative technology with work from Tobias Nolte and Andrew Witt's (2010), description of the self-optimization system that Gehry Technologies developed for the realization of the Foundation Louis Vuitton art museum in Paris. Skylar Tibbits 2015, also provides an insightful account of the 4D printing processes that the Self-Assembly Lab at the Massachusetts Institute of Technology (MIT) is collaborating on with multi-material printing company.

Nomadic Pavilions in Kuwait

For architects, small-scale temporary structures offer essential opportunities for research and experimentation – for testing and prototyping – and to get their work built and known by a wider public. Though impermanent, the majority of structures are still realized with a function or purpose, whether cultural, commercial or social. These can even go so far as to be catalysts for positive change, as described by Dan Hill ('A Sketchbook for the City to Come: The Pop-Up as R&D', pp 32–9) and Andrea Kahn ('Building Community', pp 72– 9) at a local level, and Martyn Hook ('The Affirmative Qualities of a Temporal Architecture', pp 118–23) at the international scale. Interceding even with a provisional structure with social purpose offers the opportunity to provide and to act where it may not be possible or relevant to do so permanently. As Leon Describes pavilions as 'a fairground assemblage', highlighting both the wonder and the novelty of this constellation of 'new forms' emerging as part of 'an ancient lineage'. Like ancient fairs, these temporary structures are no sooner drawing us in with their _ amboyant originality as they are disbanding. This very ephemeral nature may apply on the local nomadic

Bedouin tents in Kuwait where it is perhaps this that keeps us most enwrapped by them; you are never quite sure when they will be gone. This pavilion is a prototype catalyst for positive change utilizing emergent technology to create emergent ephemeral novel topology as illustrated in Figures (1, 2, and 3).
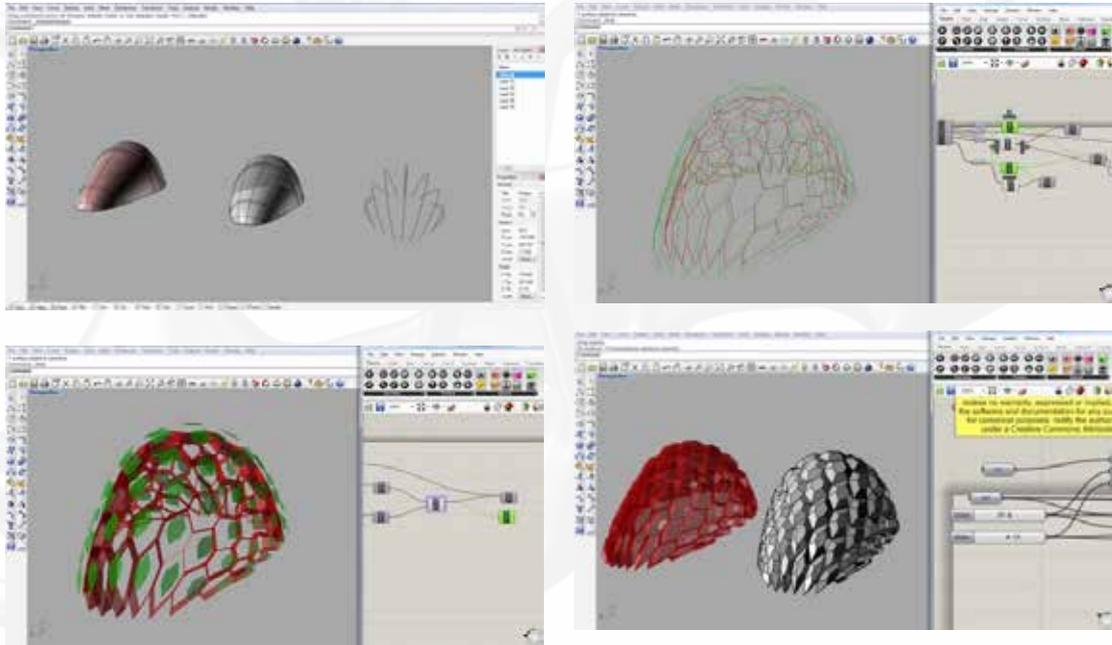
Figure 01: Parametric modeling of Pavilion 6.

Figure 02: Design and build of Pavilion.

Figure 03: Design and build of OV Pavilion.

Mega Structures in Kuwait

The National Bank of Kuwait (NBK) and the new Kuwait airport, both designed by Norman Fosters Group, are prime examples of the emergent cutting-edge technology of computational design and robotic fabrication. The author is deeply aware of the design and fabrication of these two projects. Based on multi-parameters including structures, function, program requirement, environmental performance, building materials, and fabrication technology, it is evident that both buildings forms' were parametrically designed to simultaneously deal with the above mentioned numerous parameters. This created a high degree of complexity both as a design as well as construction and fabrication process. The high precision and low-tolerance in fabrication and construction of these two projects required such emergent technology that otherwise brought the construction to a halt; emergent fabrication technology such as robotic arms for mold making and finishing treatment, Robotic Adaptive Molds (RAM) enabling free form fabrication, dynamic laser scanning for surveying and shell-cast fabrication and assembly, as illustrated in Fig. 4 – 13 below. I believe a new design culture is introduced to the local architecture design and fabrication practice.

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Figure 04: The new National Bank of Kuwait (NBK) headquarter designed by Norman Fosters Group.

Figure 05: NBK Kuwait peak lobby render image and 3D modelling.
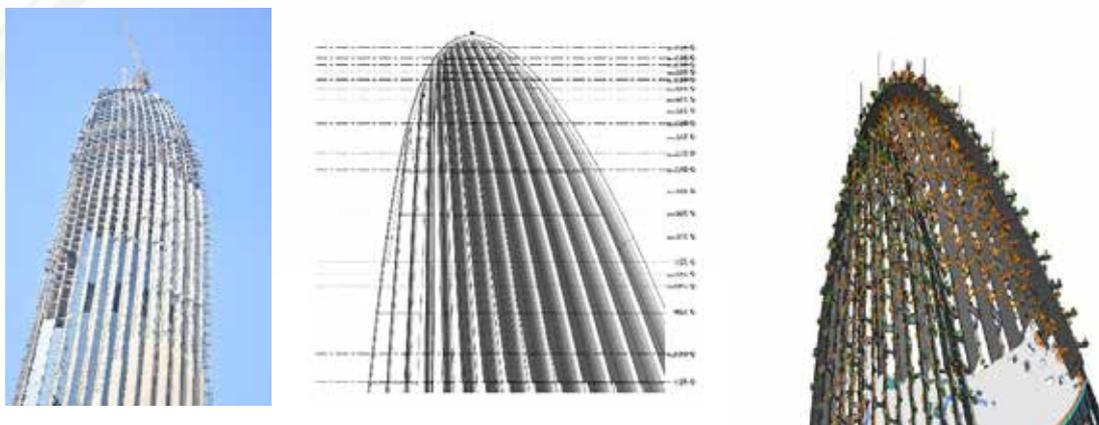
Figure 06: The complex geometry creation and fabrication modeling.

Figure 07: Three-dimensional renders of the new Kuwait Airport T2 terminal, Kuwait City.
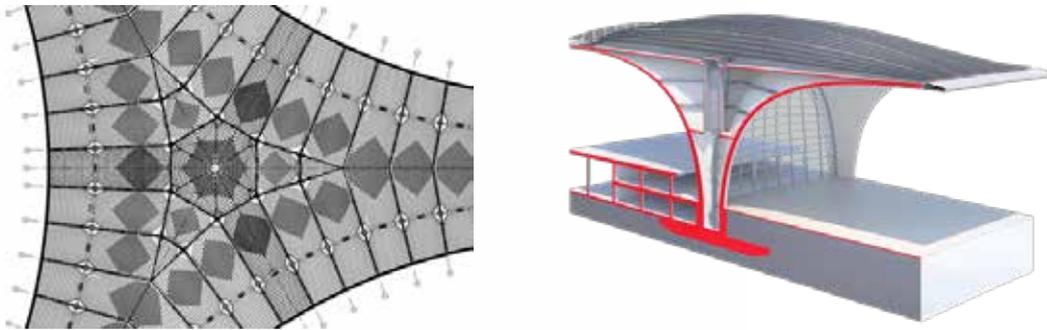
Figure 08: Structural conceptual modeling of the main structure.
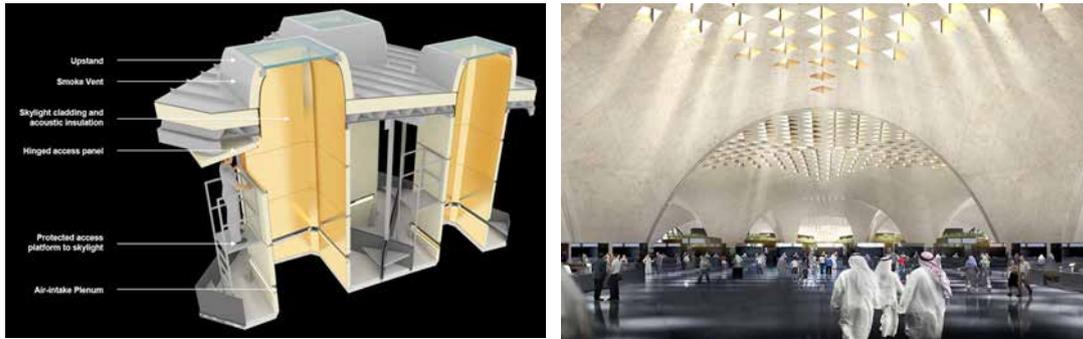
Figure 09: Day light penetration through roof.
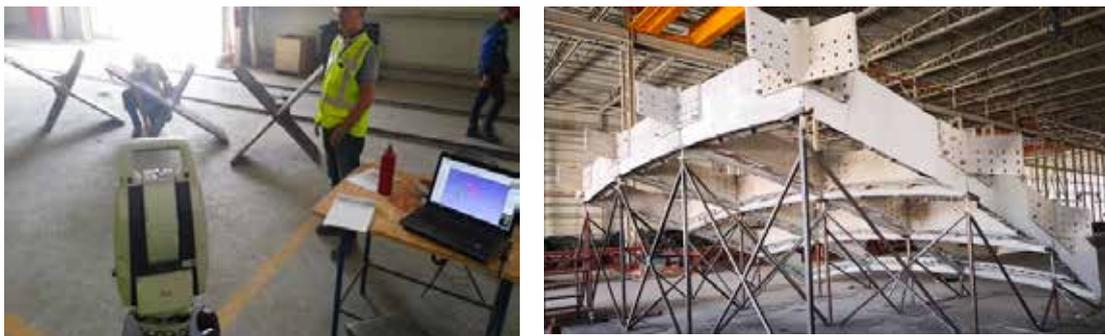
Figure 10: Shell cassettes sub- structure modeling and fabrication.

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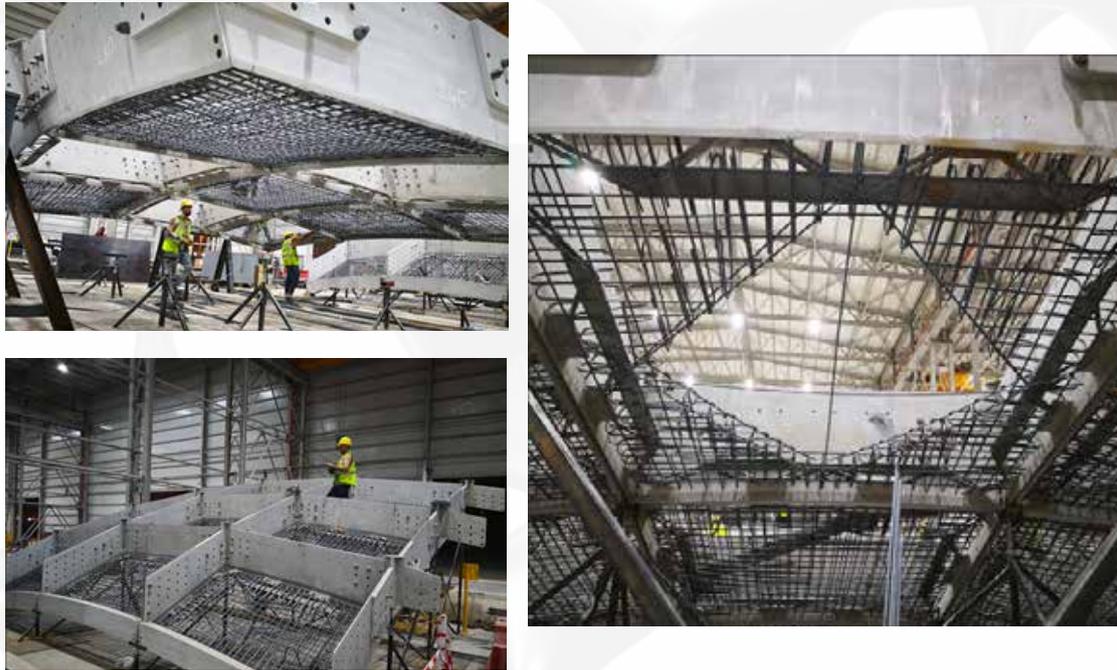
Figure 11: Shell cassettes rebar steel placed on top of Robotically Adaptive Molds (RAM) prior to concrete pouring.
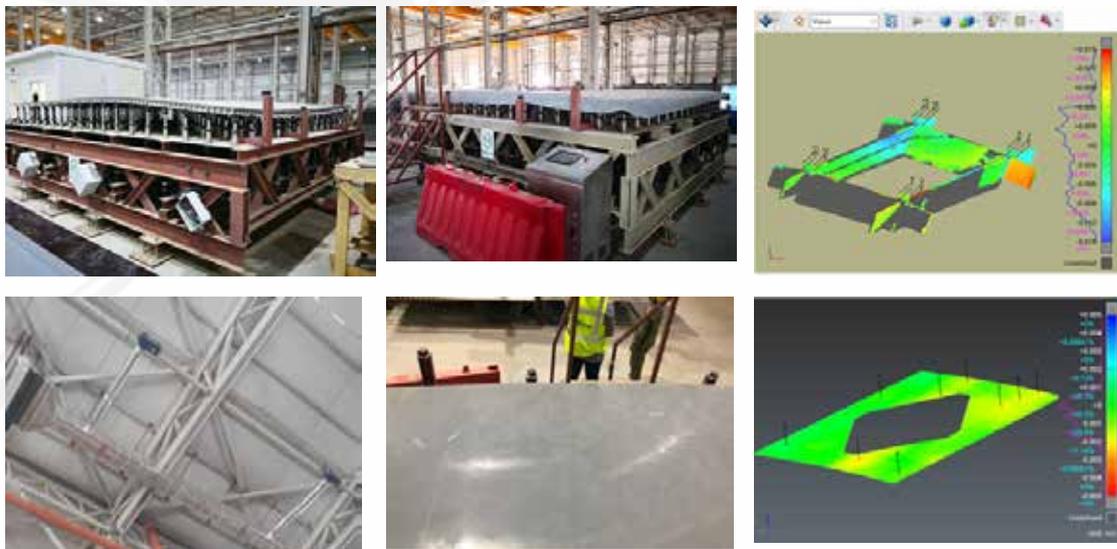
Figure 12: Laser-guided Robotically Adaptive Molds (RAM).

Figure 13: Site cast concrete pouring on top of Robotically Adaptive Molds (RAM) creating the shell cassette inner interior substructure.

Figure 14: Robotic industrial arm sand blasting shell cassettes for correct finish texture.

Conclusion

This paper tries to rethink the current architectural and urban morphologies. In recent years, the reach and influence of computational design has tended to be traced on heuristic parametric approaches dealing with numerous normally-considered convergent issues related to design, sociocultural, economic, and environmental issues as reflected by Michael Weinstock 2010, where he pushes the envelope of the current notion of the built environment, and considers the city as a dynamic complex system. He places emphasis on the interactions and connectivity of the flows through its infrastructures, and of the feedbacks and critical thresholds that drive the emergence of new spaces and urban morphologies that are animated by new modalities of culture.

It is also very much apparent how new technologies such as computational simulation and multi-scale analytic modelling are facilitating this approach, revealing a new sense of the city as one that is integrated into a complex network of flows and processes, and as much about physical as cultural properties. Running counter to the main theme of the issue is Colin Fournier's energetic counterpoint that seeks to question any assumptions about whether we need such high level precision and zero-tolerance in building construction? It also seeks to question if this emergent technology is necessary or is it mere eroticization of technology. Branko Kolarevic (2004) reminds us of the attitude of the building industry and the 'messy' realities of the construction site that design parameters are imported into.

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Re-defining the Role of Interactive Architecture in Social Relationships

Kristina Boychenko

School of Architecture, University of Queensland

Brisbane, Australia

k.boychenko@uqconnect.edu.au

Abstract

With rapid advance of new technologies and mediated built space has shifted from a static context of functions serving users to a new participant of social relationships. Interactive abilities and computational power allow built space to become smart, dynamic, and interactive, gaining agency, able to receive information and think, perceive and learn, respond and change behavior in real time. This paper considers architectural components and users as participants of a social network and investigates their agency within this network, modes of interaction and how the components of this system influence each other.

Perception of space within or outside of the building body has become a derivative of interaction between the space and the users, and therefore subject to design and programming by architects. The principal goal of this paper is to investigate the new definition of social role of interactive architecture and explain how it communicates with users, investigate the new properties it has and how does it influence users' behavior and space awareness. It reveals the importance of bi-directional communication between society and interactive environment.

Interactive space works as a mirror, reflecting social and cultural context, or a double-sided mirror allowing interactive environment to observe users and decide how to act in accordance with these observations. Within the framework of this discourse, architectural components and people are treated as agents of one socio-technical network with equal rights and agency. It considers both human and non-human elements equally as actors within a network, employing the same analytical and descriptive methodology to all actors within a heterogeneous network.

Keywords: Interactive; Socio-technical; Agency; Network; Communication; Monad

1. Introduction

Motion and information are two fundamental terms of contemporary lifestyle. It gets more apparent day by day due to rapid advance of databases and the urge of society to have fast and easy access to information and getting used to surround ourselves with smart and evolving on daily basis devices in a well-ordered space customized. This accelerated development of technologies causes dramatic escalation of demands they have to satisfy and issues they aim to solve. In the age of Internet of Things, society seeks to obtain answers to requests that haven't been made yet. Society aims at total consciousness about the world around us and at a continuous dialogue between people and other actors, sending, receiving and mediating information. Conventional built space without interactive properties is restricted in its capacity to interact with varying conditions and with the people inhabiting this space. This space is static and has only one pre-defined way of being, while thanks to technological progress it can be flowing, shifting, changeable, and interacting with its users and society. Developed technologies offer multiple possibilities for information exchange between users and built environment. This new mediated environment gains self-awareness and learns how to improve its own qualities. By comprehending itself, interactive space learns how to understand its inhabitants, therefore helping them to gain self- and social awareness, too. (Figure 1)

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As Lloyd (1998) put it, based on the words of Louis Sullivan, form should not just follow function but become one with it. This can be understood in the way that the form should not be barely a response to the function, but rather be inviting, immersive, narrating about the activity performed inside. It should answer the users' question before it was even formulated, foreseeing it and communicating the right information.

As a contemporary phenomenon, interactive architecture heavily relies on expansion of new technologies. This type of digitally mediated space has tuned into a data flow, asserting its constant transformation, offering the qualities exchange between the space and the user, society and technology. As it has been proposed by Merleau-Ponty (2017), interactive space obliterates the difference between the context and the user. The actor (or the user) is introduced by the ability to move and perceive.

Contemporary society tends to erase the boundaries between static and moving, still and reactive. New technologies allow to reduce the boundaries between the user and the space, inside and outside, virtual and real, allowing existence of the real, virtual and augmented spaces at the same time. The urban development also started to consider not only tangible, but also virtual activities.

With this in mind, the question raises: how do these opposite concepts merge? What forms the definition of the place and user or its physical representation in the world of changeability and uncertainty? How can architectural environment position itself, have identity and communicate with the world and other environments? Static identities, as well as unresponsive ones, can no longer satisfy social needs in contemporary technology-driven world. This presents the revolution of the tangible and perceptive spaces, that no can serve as medium of information, interacting with each other and other spaces and/or users, virtual and real, close or remote. All the actors of these interactions are considered as nomads, aimed at information exchange, wandering and fluctuating continuously and remaining uncertain, generating unique scenarios and communications (Mahdalickova, 2009).

By means of changing various features, including light, sound, motion and changing its components, configuration in space interactive built environment submerges the user into the atmosphere shaped for specific activities performed there, translating information and presenting it to the user in its final form. The user gets engaged in a dialogue with interactive space, following the invitation created by the space, discovering information, hidden or exposed modes of its operation, new activities, social communications, playful activities, fun situation and references that the visitors tend to interpret as the way their culture, intelligence, mood or other factors allow them to.
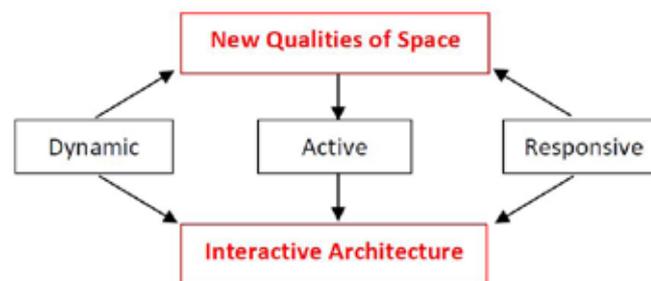
Figure 01:. New qualities of interactive space scheme.

2. Emerging Typology of the Space

The social conditions remain subject to alteration with fast developing digitally facilitated environment together with emergence of new types of space. These new space types share similar universally

applicable qualities and can be eventually considered as one new space typology, able to accommodate various functions. This shift has happened due to entering the era of cyber space and dematerialization of the world around us.

This emerged type of space needs to be mobile and adjustable so that it can successfully satisfy new and constantly changing needs of society, including social and psychological demands.

 This new space type heavily relies on technological advancement to define new ways of technologies and their application, allowing interactive behavior involving reaction in real time and dynamic spatial adjustment.

Interactive space behavior is based on the idea of bi-directional communication that involves both participants to be actively engaged in it, not merely the ability to adopt. Indeed, communication between two actors of society is interactive; they both listen [input], think [process] and talk [output] (Figure 2). Interactive space introduces the art of building relationships and communication of its components between each other and the communication of these components with the users. Finally, interactive built environment shapes communication between people, communicates with society and benefits it on multiple levels (Ishii & Brygg, 1997).
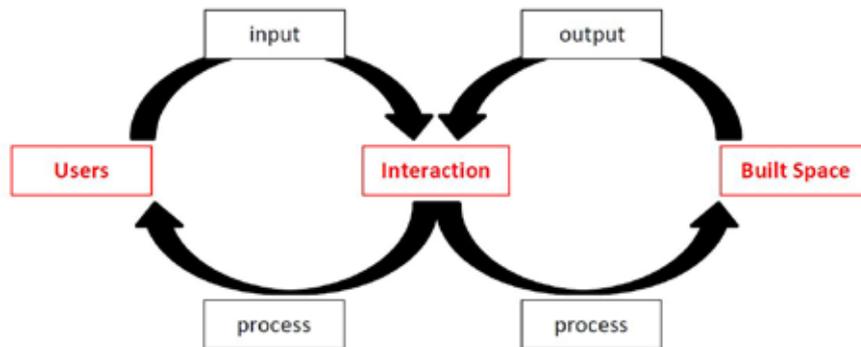
Figure 02: Concept of bi-directional communication.

Architectural space arranges social processes of interaction and plays a role in the formation and balance of social order. Architectural performance includes ownership, spatial exclusion and distinction by means of tangible boundaries with corresponding rights of access. Built space organizes social situations and provides coordination for the participants of social processes thus arranged, allowing them to find the right place of their own accord. Therefore, architectural environment reflects social organization.

A correctly located and communicated space represents an interaction, specifically an offer to take part in a particular interaction activity that is subject to acceptance or rejection by the person. In case if the offer is accepted, communicated by a user stepping into the space, the space performs as a shared ground of all members of interactive activity and accommodates all future interactions that subsequently occur within it. Merging with other design disciplines such as urban design, interaction design, sociology, psychology and many more, the space creates a cohesive narrative, an active system with broadly applicable qualities of physiognomy represented by its spatial components and the image of the built space as such (Oosterhuis, 2003).

Thanks to rapid technological advance, architectural space shifted from being a silent witness of the activities performed within it to an active participant. Computational power allowed the space to be

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smart, gaining new intellectual and intelligence qualities with development of the new technologies, obtaining interactive properties and eventually its own agency. The space is not limited to adaptation to various conditions but actually becomes the receiver, the processor and the translator of data, reacting to the new conditions and learning to communicate and act. The concept of spatial agency relies on translation of received information, like visitors' motion, location or voice commands, information about the environmental conditions or other factors. Therefore, by communication with society, interactive space becomes an actor in social relationships, changing and responding to other actors and changes of the context. This paper considers interactive space as an active part of social relationships through the Actor-Network theory. This way social relationships are considered as parts of common network where visitors or users (human) and space components (non-human) actors all have agency. Interactive behavior is defined as the ability of all components, human and non-human, to demonstrate agency, creating unique situations and communications in real time. (Boychenko, 2017) (Figure 3).

Built space has to refer to specific context, physical or digital. For example, the space can be linked to another space or spatial component, located elsewhere. Architecture must be linked to other environments, analogue as well as digital. Multimedia approach allows to create new types of interactions between the space and the users or another space, introducing universally distributed information exchange, a groundbreaking extension of the space into the new dimension. The space has become active and able to offer not just a set of structural components and functions but creating dynamic situations.

● Hunan actors of the network

● Non-human actors of the network
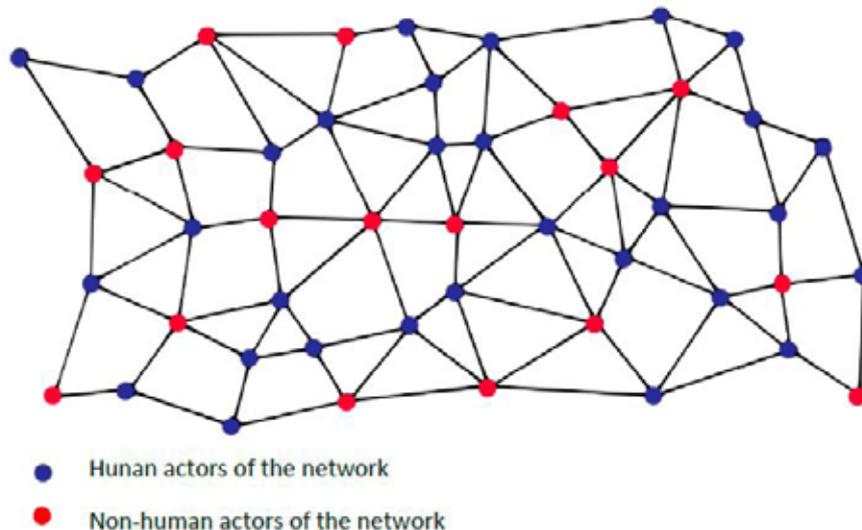
Figure 03: Human and non-human components within a homogeneous network.

Connected to other systems, interactive space can become reprogrammable, thus adaptable to various emerging conditions and situations. This unique ability to stay updated leads to adjustability of the space for different and changing functions, making it a crucial factor of the spatial performance in social network.

Social conditions can be reflected through architectural space in the following ways:

      - shape adjustment to satisfy users' needs

- space adaptability for various activities

- connection to remote spaces, devices or users

- space extension within the network

These new qualities allow the space to adjust to new conditions and react in order to maintain communication with society on a new level culturally, acting as a time transmission. The time that can accommodate all sorts of content. This way the space communicates not merely a function, but also information, changing through time. "The result is the rise of Digital Gothic", as Kas Oosterhuis,2019 puts it.

3. Space Behavior and Consciousness

Behavioral design is largely referred to as a type of design that can successfully satisfy various users' needs, as well as respond to their feelings and the way they occupy the space, showing awareness of the current social structure and the ways users communicate, adjusting to emerging users' needs. This concept considers behavioral design qualities and interaction of the space that acts as the context of the users 'activities and behavior.

Combs and Brown (2018) in their book argue that behavioral design can be executed to its full potential when it correlates with the idea of transparency, benefits social stability and is targeted at satisfaction of users' desires. While behavioral design is aimed at persuasion of users, it also must be ethically reasonable and respect users' intrinsic rights to freedom of choice, autonomy and dignity.

When the cue in the space is perceived by the users, they tend to learn to associate the cue with a certain action (behavior). By performing the action, users get rewarded for it (meeting the consequence of their action). A good behavioral can place created cues in space to cause certain behavior by users (Kong, 2018).

Since interactive architectural space has agency of its own, it certainly also has the intelligence of its own. Conscious spaces become active members of society, understanding the world around them, sharing a common goal that the machine understands its meaning, hence acquired initiative that drives its endeavor to search for the answers and ways of performing.

Intelligent spaces within the framework of this paper share common understanding of the world with users, developing knowledge and understandings of the world through interactions between them and the physical environment, responding differently to interactions with the context and other bodies (Oosterhui, 2006).

Understanding Users

Interactive space allows to create immersive and compelling experience and influence the way users perceive this space and the way they act there. There are different strategies to do that: one is to persuade people to level-up during a fun and engaging activity. Some researchers claim that it has positive impact on emotional state, productivity and creative thinking. Another strategy to achieve this effect is to create the environment addressing its function to playfulness while allowing benefiting through playful behavior.

According to Anderson (2011), there is a formula of interactive space:

Delight/ Fun + Exercise/ Achievement = Interactive/ Immersive space

The space resulting from this formula focuses on interactive space behavior as a tool, allowing to feel engaged, actively present in the moment, focused on the activity and immerse into the social and

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physical context of the moment and situation.

Interactive space is considered to be enjoyable due to immersive way of spatial experience, creating individual communication with the context and expression through play/interaction. This interactive behavior of communication with the space leads to emotional affection and attachment to the space (Andeson, 2011).

Learning from Users

There are various ways of influencing users' behavior through spatial means. First of all the space is required to learn how to understand the users. By utilizing various learning mechanisms, for instance distributed adaptive control, intelligent space explores effective cues that can be perceived by the users and followed by a certain behavior. By understanding users, interactive space applies bi-directional symbiotic method to communicate between the users and the space, allowing them to perceive and affect each other.

People often demonstrate the desire to learn new behaviors naturally if they are well motivated. At the same time, interactive space behavior heavily relies on the users' performance or other factors. Interactive space can communicate with users via the cues about the activity within it, the direction of movement, possible ways of using spatial components, other users etc. Smart space often has the ability to track users and analyze their willingness to follow the cues it provides. This way the space learns what cues are effective and adjusts the way it communicates.

While use of voice-based commands and gestures cannot be applied universally and can cause misunderstandings in different social groups, the communication between the users and the space can be successfully achieved by using non-verbal language of space alteration. The space can effectively use light, sound and motion as output and tracking, cameras and sensors as input for communication. Unlike spoken or written words of language-based communication, non-verbal means of communication allow to avoid antropomorphization of the spatial components.

Within the context of this paper, talking about smart spaces refers to space perception as the main feature of communication, introducing the intelligence that is now extended in its efficacy by the sensibilities of affect. This means that the users' communication with smart spaces relates to, arises from, or deliberately influences emotions.

4. [E]motive Design

According to Picard (1997), emotive design refers to affective. Effective rationality requires emotion as one of its' major components. Affective computing constitutes some shared hypothesis. First, affect implies a particular domain of cognition that can be addressed through analysis of its components. Affect is introduced as an expression of an underlying emotional state. Suchman (2007) argues that affective communication can be achieved through the "replication of behaviors understood to comprise it, made up of units assembled into a catalogue of affective expressions, productions, recognitions, and normative responses." [E]motive states of design and their affective expression can be considered as a kind of primal but still functional ancestor of contemporary reason.

5. Pragmatic vs Humanistic

Pragmatic applications of interactive architecture are targeted on solving issues, satisfying demands and systems optimization. It suggests numerous improvements in comparison to static architecture like the enhancement of the building's ability to meet functional demands, its security, flexibility and adaptability, image, reliability, energy consumption, expenses and cost, and easiness in using it; optimization of visual, acoustic, thermal and other conditions, meeting the changing requirements in

public and private space, accommodating special needs and desires. It is the answer to how architecture can help the inhabitants to perform their activities or give advice on how to use the space in more efficient, sometimes unexpected, ways, or providing them with more suitable conditions for their tasks.

The humanistic approach is aimed at analysis of the impact of interactive space communication of users' physical, psychological, and social conditions, referring to artistic implications of the space. It considers the design of dynamic spatial components linked to the way users perceive the space and behave in it, moving and shifting their vantage point. Hoberman (2007) talks about the influence of motion on emotional state: "When one sees this special behavior [of transformation], one feels it in one's body - perhaps a physiological connection, because there is a sensation, a physical sensation and a mental perceptual sensation."

Since very early in the development of interactive space design as a field, the description of a new world where buildings have evolved alongside a futuristic society to assume new functional and social roles has populated the imagination of architects. This expectation is justified by two reasons: first, because it is known that technology has the potential to catalyze profound cultural transformations; second, because interactive architecture carries the potential to cause unprecedented shift to buildings' capabilities, which have otherwise evolved at a very conservative pace.

6.   **The Perspective**

The concept of spatial agency can be appreciated through a cybernetic perspective. Following the assumption that every interactive system has an internal goal, that makes feedback structures conceivable, then every single interactive system should have some degree of intrinsic agency, which does not necessarily mean complete autonomy or intelligence. Therefore, extrinsic agency of space o spatial components means that every interactive setting also has intrinsic agency (following Bruno Latour's definition).

Cybernetic background explains the initial relation between interactive space and users' agency. Being the key figure in the second-generation cybernetics, Pask (1969) addressed the importance of feedback in systems design and components specification in space design. By means of smart systems, interactive space can become active participant empowering environments by including the users as participants of a larger control loop.

According to Pask (1969), "the designer is no longer conceived as the authoritative controller of the final product" of the interactive space. On the contrary, "an environment should allow users to take a bottom up role in configuring their surroundings in a malleable way." Haque (2007) referred to Pask's approach to architecture in the following way, "it is about designing tools that people themselves may use to construct — in the widest sense of the word — their environments and as a result build their own sense of agency" (Pask, 1969).

 In general, the idea of interactive space behavior often referred to the concept of user empowerment in the last century literature. It is argued that early addressing of interactive behavior in media studies sought to subvert traditional systems that helped reproduce power and social relations.

Conclusion

Interactive architecture is dynamic and time-based, meaning it changes its performance (in terms of space or in terms of behavior), demonstrating a significant shift from static and fixed. Users become parts of performance within the context of interactive environment as they do also change over time.

Both built spaces, space components and users can be considered as actors or small particles within

one homogeneous network, constantly perceiving each other and changing accordingly; monads within a system, aiming at achieving a common goal. They demonstrate swarm behavior and spatial as well as social awareness of each other's actions, constituting a system where their roles are defined by the same set of rules. Both human and non-human participants become interchangeable monads, able to influence the system with the same or equal degree of agency in this universal decision-making process.

Within the framework of social communication these monads as the result of their interaction create unique social relationships and play equal roles in this communication, influencing behavior of other monads, changing and adjusting to them. Spaces shape the ways users behave in it and influence the ways they interact with each other and the space, while the users change the space performance, improving its behavior and creating unique customized spatial organizations.

Berkel (2009) said that the value of our architecture is to inspire the users to generate ideas and images, therefore to make it attractive to people, to make them stay longer and come back to places that the architects create for them.

Functionality and value can be found within the object and at the same time is superimposed on its cover. Architectural mediated spaces have turned into complex adaptive systems, interacting with environment, outside and from within (Kemp, 2009).

Communicative performance of public spaces incorporates social and cultural properties of space. A plethora of case studies within the discipline demonstrate taking advantage of the medium to engage society through participation. Purposefully designed, specially defined interactions are utilized to comprehend, organize and stimulate social communication. While tangible architectural environment means are utilized to accommodate functions, navigate the flow of users of the space and allow or limit their movement within the space, interactive spatial means focus on having significant effect on social interactions (Marialuisa, 2013).

Interactive components of designed space provide attachments and communication scenarios, which allow congregation of the network actors, forming various groups, assembling social diversity, linking heterogeneous elements and effects, thus adjusting and enacting the social, triggering foreseen and unforeseen situations.

Architecture that lacks interactive properties can successfully accommodate physical function and communication between people, playing the role of silent contextual background, offering shelter and non-communicative passage through it. At the same time, interactive qualities make the space a participant of social relationships, shaping it and persuading a dialogue between the society, represented by users, and the space. Smart architectural environment actively participates in unique situations and shapes experience, involving users individually and as social clusters in various activities, offering them to communicate with the space on individual or group level. Interactive environment and users get involved in a real time dialogue, stating further modes of their communication and shaping new experiences.

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Crossbreed – (Re) producing the Future

Yael Brosilovski

Director Yael Brosilovski Studio

yaelbrosilovski@hotmail.com

Abstract

The subject of technological intervention has been largely debated among the world's greatest minds. Political, theological, psychological, biological and ethical implications have all been argued for and against the 'technological other'. Does the fact we now CAN perform certain operations and changes to the human body and society at large actually mean we SHOULD? What impact can we foresee with unlimited human intervention in nature 'as it was intended'? How can we benefit from an era of information flow, where crossing and hybridizing-disciplines, or as I term it "crossbreeding", become the new breeding ground for innovation? How would Architecture be affected by a future that belongs to organic, non-organic humans and anything in between? This paper will discuss these issues and take a peep into where we might be headed in the near future, so to better understand the challenges that are ahead of us.

Keywords: Technology; Crossbreed

1. Introduction

The emergence of the world-wide-web in the 21 century has brought about an evolutionary shift to life forms, as we know them, and the emergence of the "Crossbreed". The unpredictable evolution of the internet superhighway opened an access and speed of information like never before and brought about more possibilities for inventions by hybridizing and crossing-over information from different disciplines. At this very day and age, as we speak, labs around the world are working effortlessly to create and re-create new life forms with the aid of technological interventions. Human and animal clones, artificial wombs, nano-robotics, cyborg engineering, bionic prosthetics, artificial limbs, regenerative treatments, extension of life-span projects and genetic engineering, if to name a few.[1]

The subject of technological intervention has been largely debated amongst the world's greatest minds. Political, theological, psychological, biological and ethical implications have all been argued for and against. Does the fact we now CAN perform certain operations and changes to the human body and society at large actually mean we SHOULD? Take for example "the artificial womb."[2] Beyond the theological questioning as to whether we should or not intervene with nature "as it was intended", multiple political and ethical questions arise. How would the role of an artificial womb, which practically means an embryo, being grown in a see-through plastic bag plugged into tubes acting as the umbilical cords in a lab, change the role of women in society? Would their much-valued role in creating life and reproduction be sidelined? Would they therefore be further removed from structures of power in society? How would it affect their very core and well-being having their

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1 As cited by Hashem Al- Gaili re lifespan extension: "Scientists are working on new ways to reverse ageing in humans which will improve our overall lifespan and body function. Every chromosome has a protective cap at its end called telomere. Length of telomere is directly proportional to human age. As we age, our telomeres become short, leading to the death of our cells. A naturally occurring protein in humans extend the length of telomeres. Scientists are trying to artificially increase the production of this protein." (http://www.cell.com/cell.../fulltext/S2211-1247(18)30156-6)

2 Experiments growing lambs in "biobags" turned out successful. Eight lambs were delivered prematurely. They were moved to external "wombs" to continue developing. The biobag protects the fetus from the outside world. It consists of a plastic bag that mimics the mother's uterus. An electrolyte solution inside the biobag helps the fetus develop. The lambs' umbilical cord is connected to a device that replenishes blood, oxygen and nutrients. For nearly a month, the lambs' lungs and brain matured. They grew wool, opened their eyes and learnt to swallow. So far, the biobag has only been tested on sheep but it is expected to one day help grow human babies as well.

biological "intent and purpose" taken away? What would it mean for the mother-child bond? Would it disrupt the human connection previously formed in the womb? Would the human connection be as strong with this physical detachment? Furthermore, can we be certain we cracked the code and fully understood the mother-embryo's biochemical exchange throughout pregnancy, so we can be sure to mimic/ replicate it in the very same way at any a given moment? And how and for how long do we need to monitor differences in development of embryos bred artificially to be convinced they will later develop as their naturally bred peers?

Despite these unnerving questions, the quest for transformation prevails. Perhaps, maybe paradoxically (time will tell) it's a process of self-preservation. We are naturally curious and seek the unknown for the betterment of our species, for the sake of survival or simply for what we believe would be a happier life. Most of the technological projects at stake intend to better our chances of survival. So, if we are to go back to the case of the artificial wombs - wouldn't it be nothing short of miracle to enable all of those who wish for it – a chance at creating life, extending possibilities to what "nature has intended" and sometimes failed at doing so? Can we intervene at helping nature to better itself?

2. When Dreams (Can) Meet Reality

If nothing else, technology has brought us multiple steps closer to bridging the gaps between our dreams and reality, or at least seemingly so. Perhaps in several decades, we can fulfil the dream of living eternally, healthily[3]. Perhaps we can even choose what our children will look like, what of their future defected genes to eliminate in order to prevent diseases. What genes to alter, so that they can be more beautiful, stronger and smarter. You get the picture. The question is where, if at all, intervention ends? And what would intervention in a capitalistic world look like? Don't even get me started on that…

The "Crossbreed" project is well underway. It is almost as natural as natural evolution. It happens in small incremental steps, almost unnoticeable, simple sneaky life upgrades, that later blend into our daily life and become the norm, not too dissimilar to how chemistry and drugs have integrated into our bodies a century before and now became a matter-of-factness. In fact, could you imagine living today in a drug free world? Perhaps the next century we will look at all these seemingly threatening technological innovations in much the same way.

3. Designing for Crossbreeds

In the parallel world of Architecture, it is important we think and respond to these "evolutional" changes. After all, it may not be humans (as we know them) at all our future buildings will be intended for. Rather, from what we observe in the techno-scientific world, they might well serve a concoction of some form of organic humans, non-organic "humans" and anything in-between. We need to project ourselves into a future where humans and robots interact, not necessarily in a sci-fi apocalyptic manner[4], but in a scenario that is as simple as daily interactions at home, between us and our robot vacuum cleaner, our robot clothes steamer, our robot cooker or our "Alexa". The Japanese went as far as inventing a holographic "girlfriend" who'd be programmed to be animated in welcoming you with a cheer at the end of a hard-working day. And she only trades at $3.7K.[5]

3 As suggested by Yuval Noa Harari's book Homo Deus – A brief history of tomorrow.

4 Such as implied in films like Ex Machina, Gattaca or Blade Runner.

5 As reported on Bloomberg website, the virtual hologram girlfriend has been developed by the Japanese company GateBox. Its founder wished to come up with a girlfriend that interacts in a friendlier way than her human counterpart. According to research conducted in Japan, 70% unmarried men and 60% unmarried women aged 18-34 have never been in a relationship with the opposite sex. This emotional void has been taken on as an opportunity for capitalizing on. Hikari Azuma is a blue hallowed Japanese cartoon figure who is promoted as the "wife of the future". She can wake you up in the morning and greet you when you get home. When it gets late, she might suggest going to bed and say goodnight. The hologram device could be attached to a mobile device so as to continue the "relationship" long distance while at work with a chat app. "I want to make her into a person who understands her husband. Because there is some distance, it may put her "owner" at ease as he doesn't need to chat with her all the time", he says.

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We may need to start thinking of another level of smart homes, that expand and shrink according to our spatial needs, that self-clean, self-maintain, that can change colors, light & sound according to how it senses our mood to be, that learns our behavioral patterns and knows how to adapt to them without us having to ask for it etc. Furthermore, in a "crossbred" world, where already in-use bionic limbs enhance our physical capacities tenfold or more[6], how would the physical properties of a building respond to these newly abled bodies? We may have to re-think building ergonomics entirely.

4. Negotiating New Body/ Space Boundaries

Beyond private spaces, we may have to re-consider the demarcation of building typologies as we know them and start "crossbreeding" intended usage. With the growing ease of telecommunications one ought to question whether the definition and use of "home" should remain a space for nesting in after a long day out or would it turn into much more of 24/7 type of functioning hub from which one works, entertains, eats, sleeps and lives? In such a scenario, the office could become a relic of the past, as virtual meeting rooms and networking forums replace the physical boundaries of such working environments. With this in mind and the gradual erosion of other social environments such as shopping malls in favor of e-commerce and even physical universities in favor of online degrees in our digital era, new typologies emerge and more should be dreamt of. For example, the fast growing "WeWork" model of shared workspace for entrepreneurs has tapped into this new market of people seeking to meetup, socialize, enhance their network of connections, yet with great deal of flexibility – flexibility of working hours, locations, size and level of intimacy of rooms and spaces and even of the moods of the spaces. They have dreamt for them a new typology to do just that. A place to hang out which is somewhat between an office and a beach café. And they pop up everywhere worldwide, like mushrooms after the rain.

Construction methodologies and development in tooling is another category to benefit from digital advancements.[7] With the inventions of 3D printing, a world of possibilities has opened up especially but not exclusively in the product design sector. Culinary, jewelry, fashion, interiors, art and even "wearable architecture", have all been playing with the possibilities the tool has to offer. In architecture, the progress is slower yet demonstrates interesting potential[8]. In an era where a dress, a cake or a ring could be quickly picked and customized, to fit in with what a customer wants and needs by 3D printing it, could a whole home (or parts of) be 3D printed or modified on demand? Furthermore - If architecture can inform and inspire a piece of jewelry, why can't a piece of jewelry inform and inspire space making? The introduction of 20th century mass produced homes, and today's precast technologies have been instrumental in making homes more affordable, faster and easier to construct. 3D printing could be the next level upgrade, whereby, parts of homes will be designed and selected virtually from a catalogue, erected and assembled off-site, then transported to be "slotted in" to an existing or new project, much like Lego assemblage, with the great added benefit of freedom of form.

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6 Some examples include the retinal prosthesis system (or simply – a bionic eye) developed by scientists around the world that will not only help restore sight to the blind but for those with normal eyesight could soon have UV vision and Zoomable lenses on their very own retina, this can happen as soon as 2020. Ford's EskoVest, an unpowered upper body assistance exoskeletal vest developed in conjunction with Esko Bionics is another application designed to reduce injuries and worker's fatigue in the auto-factories and boost worker's morale. It offers 5-15 pounds of lifting assistance. This is to assist workers with overhead tasks.

7 For example, the self-build concrete block system by Armados Omega reduces construction time by 50% and requires no binders due to its unique interlocking system, similar to puzzle, but in 3D.

8 Prof. Benjamin Dillenburger for Digital Building Technologies at ETH Zurich, for example, developed a hybridized technique to use 3D printing with concrete casting. In his research, Dillenburger 3D prints the inverse of the concrete forms and uses the 3D print as the formwork rather than printing the concrete itself in 3D. This way, complex and bespoke geometry is no longer an issue to overcome. An added advantage is the added productivity by economy of material use. Unlike traditional slab casting methods, here slabs are thickened where stress is greatest and thinned where stresses are less critical, so tailored to structural specificity.

5. Who's in Control?

Beyond the capacity of the human mind, its wants and needs, the next generations will have to respond to environmental consequences of their predecessors. With global warming, rising sea levels, natural disasters, extreme temperatures and mass eradication of species etc. we are likely to witness in the not too distant future, mass migration of populations. This will likely affect natural habitats and architecture will have to respond to that. New forms of transient structures, a modern version of the nomadic tents if you like, are likely to emerge. Construction that is designed to float over water, much like the boat, or burrow into the land is another avenue to explore. Architecture may have to come up with solutions for quick transitory needs and could resemble more habitats in nature such as the nest or the burrow rather than the permanence of "the great wall of China".

The implications of the accelerated loss of control human beings experience in this transitional period towards the digital age ought to be reflected upon. Our future jobs, so we learn, will be mostly replaced by robots. Our future cars will mostly be driven by auto-pilots. Our future babies may be bred remotely from our body in some plastic bag. What would be our societal purpose in such a life? How would we "fill" our newly found void in the form of free time? Shouldn't we be more occupied with imagining a new way to "be"? a new way to "live"? "Design" our species' future life?

Similarly, in Architecture, we may need to re-examine the model of the city with a fresh outlook. If life on earth will be more transitory and work will be possible to conduct from anywhere – what purpose does a closely-knit urban environment any longer serve? Will this mark a start of withdrawal back to country living?

It isn't just about the redundancy of our most basic daily human actions that is about to change. What we already experience, and this is likely to intensify, is the redundancy of our most intimate body-temple, a redundancy of our innermost primal senses. With the introduction of the screen, no longer do we remove ourselves from close contact physical human interactions with others, but we also remove ourselves from our very own bodily senses, that of touch, for example. The more we 'live' in virtual environments, the more removed we become from the use of our senses. How would the next generations of humans develop as a result? Will they mutate and evolve into a whole new differentiated species, algorithmically skewed from the model we live by nowadays? If so and until that happens, how do we compensate on the loss of our senses, the satiety for touch, through the physical environments we do still use and inhabit?

6. Budding Responses – Research and Practice

In the past several years, I have been shadowing projects in various fields that fit into the category of the "crossbreed". Crossbreed not only as a noun or an outcome, a cyborg, a hybridized project etc. but also, as a verb, an active agent. Taking ingredients from different disciplines and putting them in the mix to later find a new, enhanced flavor. I do this through my **Crossbreed** Facebook page[9], where I document a collection of interesting projects, past and present that fit into this active definition.

In parallel, I have also started working on personal art projects that cross between the analog and the digital, the virtual and the real, the body as experienced and as conceived. I find the process to be enhancing rather than compromising. There are weeks I would only explore digital possibilities and would later opt for analog versions of them, not as a copy, but as a next step, an evolution of what outcome I've had come up digitally (e.g. Figure 12, "the evolution of an oddity"), and vice versa - sometimes the whole process will start with a sketch or a painting that I will later explore digitally (as e.g. Figure 6-10 from painting 'becoming' and 'currents' followed by a series of vector field studies digitally). From these experiments I find that one process feeds the other.

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9   https://www.facebook.com/crossbreed.me.

The digital realm is exciting and surprising as it often feels like you're not the only author of your piece. There are other hidden gamers there, that take your initial intention and parameters and turn them into something often unpredictable. Then its over back to you, and you continue the next step from there, until an extraordinary work of art emerges (e.g. Figure 3, "the evolution of an oddity" was about exploring digitally connective lines between points along a geometry, the result of which I could not have predicted. Instead I evolved the geometry in incremental steps, twisting and turning and adding complexity until eventually I reached the desired outcome). This process is quite different to an analog process whereby you'd pretty much need to know in advance where your piece is heading, or you'd at least let your intuition lead you.

I personally conduct my work of "crossbreeding" with different methods of expression. I paint, sketch, sculpt, create 3D models, render, algorithmically generate, and weave threads over canvas (Figure 12 – "turbulent times" started as digital construct creating turbulence within a specific geometry. I later made an analog version by using cotton thread over canvas).

I found that many years of working with advanced 3D generative software has led to an in-built bodily intuitive response, a kind of muscle memory, to shapes and forms and has helped free movement and structure in my analog work. Digital simple rule-based geometry finds its way intuitively into my paintings[10] (Figure 6-10). I am also interested to further explore the relationship between digital animation and physical, time-based structures[11] (Figure 13 – "The dance – a human mandala", where the animation of a circular array of identical dancing figures are creating different patterns on different animation' frames, which in term can inform a dynamic kinetic, ever changing structure). At the other end of the spectrum, exploration through the analog work sometimes leads me to further develop those ideas via 3D modelling and exploring possibilities that unless working with computers, I would have not been able to foresee.

7. Conclusion

Architects and Designers in the digital era ought to address the fast-changing landscape of technological intervention as in parallel fields and engage with it positively, exploring further its potential to the industry. Aspects of change should be studied from various perspectives – how do we design not only for humans but also for robots as well as for crossbreed cyborgs? How would advances in materials and construction methodologies bring architecture forward, in a more radical way both in form, economy of material use, data driven user patterns, security and ease of construction/assembly? What is the potential of hybrid architecture consisting of overlap between the physical and the digital worlds?

With that in mind, we also ought to acknowledge the fact that we are not capable of predicting all outcomes and despite careful planning we may still be up to surprises that will require speedy responses. Climate change, unpredictable and possibly out-of-control development in technology etc. may require emergency exit strategies through advance planning of e.g. temporary structures for transient usage or highly secure buried structures to withstand any potential catastrophes.

Our community should engage positively with possible outcomes to the betterment of all inhabitants of earth, find new modes of social engagement that the erosion of physical spaces entails as well as rethinking the way we may live and work and conduct our everyday selves in future. Lastly, we ought to consider ethical as well as psychological implications of the human sense of loss of control in ways that openly deal and counteract fear and resentment through user-friendliness, user-empowering technology, responsive 'living' structures, humane, tactile additions to our future environments as well as re-thinking building or virtual spaces to enhance social interactions and counteract otherwise possible isolation.

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10 As in the paintings "Becoming" and "Currents" for example.
11 Such as in "The Dance – a Human Mandala", where the collective motion of the circularly arrayed dancers create a kinetic Mandala-like structure and pattern. Similar analogy could be drawn to kinetic structures in Architecture.

I find this time to be very exciting for artists, designers and architects, in that, technology enabled a new paradigm shift for hybrid mediums. It doesn't need to be defined as this or that. Rather than separation and demarcation, crossbreeding should be setting the tone. Crossbreeding between art and science, art and architecture, science and architecture, the natural and the artificial, the rational with the intuitive, the digital with the analog etc. but also within the architecture field itself, let us not ditch the value of the human-hand eye coordination, of human emotion and intuition. We ought to find new ways to incorporate those into the digital work by "crossbreeding" the two.

With the computer's advanced mathematics and processing capabilities, the capacity of digital art, design and architecture is extended beyond the eye and the hand, beyond human perception. New visual vocabulary is now possible – intricate forms, complex geometry, user's data analysis, security systems etc. The implications for art as well as for architecture are infinite, as since it can be visualized, it can most probably be constructed. As mentioned previously, with digital technologies our dreams and wants are so much closer to reality, since

IF IT IS (DIGITALLY) IMAGINED – IT IS ALREADY REAL.

Upper Image **Figure 01**: A Changed Man – The human condition examined through parametrically manipulated 3D sculpture, Lower Image **Figure 02**: Displaced Man – parametrically manipulated 3D sculpture.
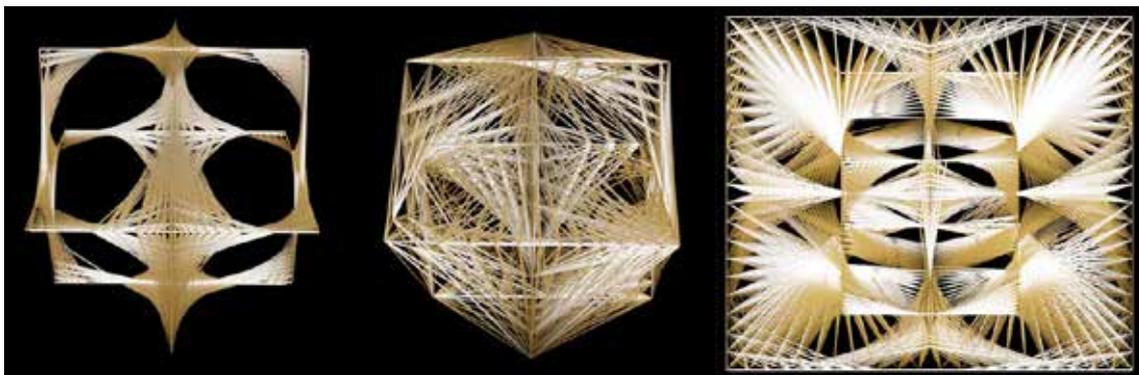
Figure 03: The Evolution of an Oddity – Simple algorithmic rule base of connective strands develops into a fully-fledged artwork.

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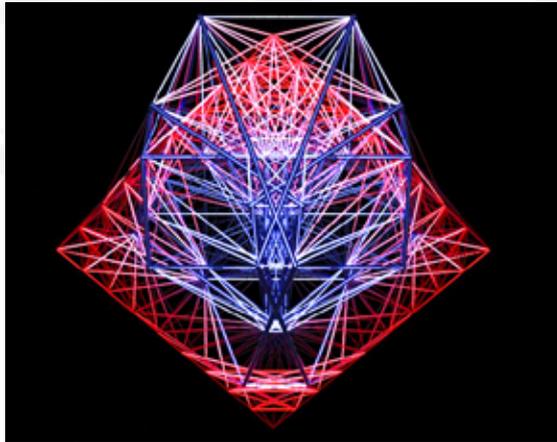
Figure 04: "Untitled" - Imagining Alternative Kinetic Structures / Spaces that adapt to user patterns.
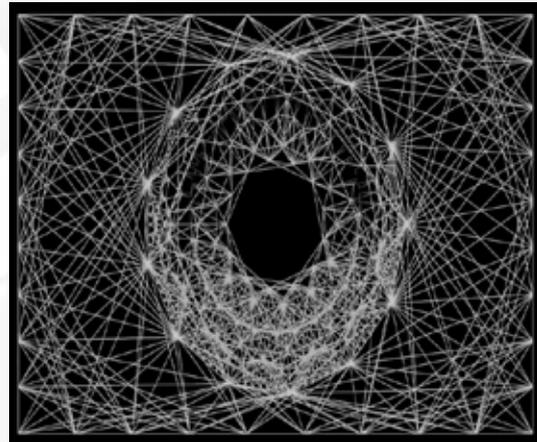
Figure 05: "Untitled" - New Possibilities - Digitally manipulated strands creating 3D woven lace-like 3D structural space.

Figure 06: "Becoming" – Simple rule-based Hand Drawn Algorithm - Acrylic and Marker on canvas.

Figure 07: "Currents" – Simple rule base painting – Acrylic on canvas.
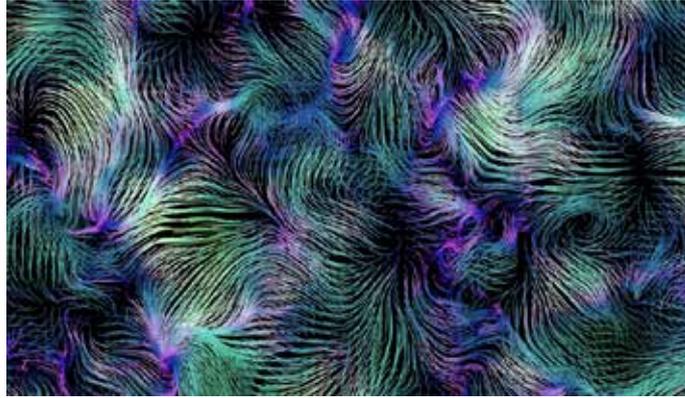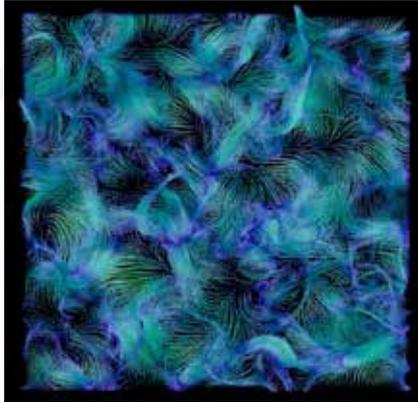
Figure 08: "Vector Fields Forever" – Following up the direction of hand drawn "currents", I explored the visual and spatial potential of vector fields in 'Houdini' software. Starting as a grid of points and "growing" geometry out of those, later subjecting the result to multi-directional forces, creating a chaotic highly tactile, hair-like space within the order.

Figure 9: "Vector Fields Forever.".
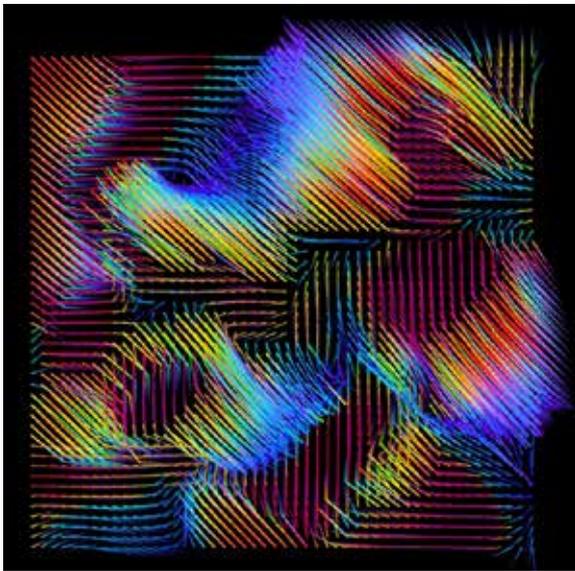
Figure 10: "Vector Fields Forever.".
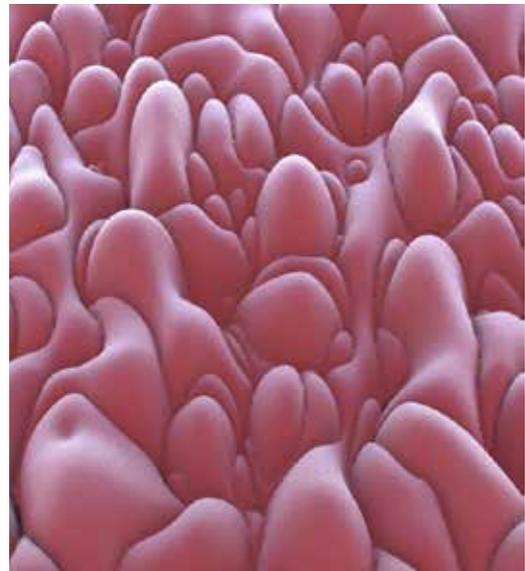
Figure 11: "A Soft Spot – Please Do Not Touch" – Digitally generated 3D Sculpture responding to the increasing need to compensate on loss of touch in the digital era.

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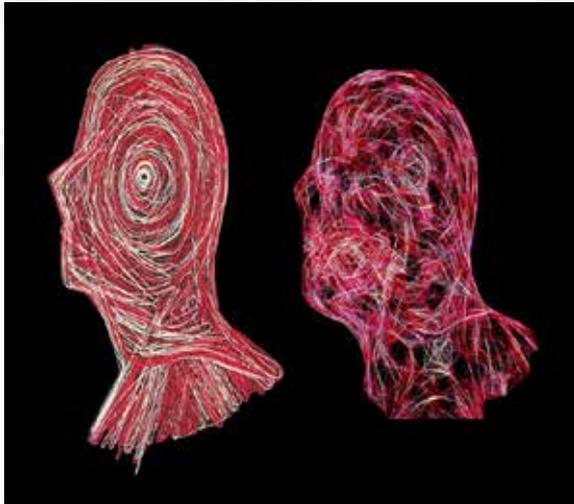
Figure 12: "Turbulent Times" – The digital and the Analog work process informing one another.
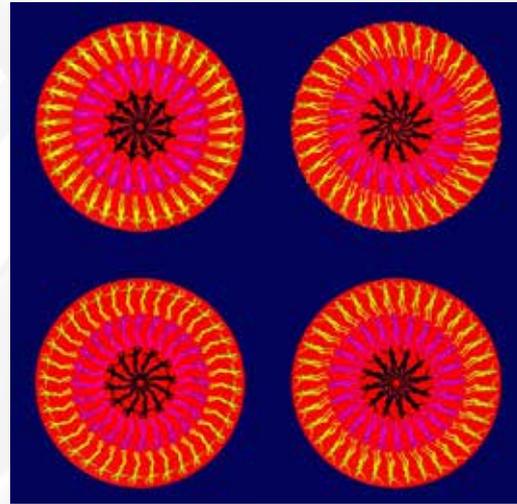
Figure 13: "The Dance – A Human Mandala": Stills from an animation - The structure changes over time to create differentiation in pattern.

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The Agrarian City in the age of Planetary Scale Computation: Dynamic System Model and Parametric Design Model for the introduction of Vertical Farming in High Dense Urban Environments in Singapore

Tabony Aiman[1]; Llabres-Valls Enriqueta[2]

[1]PhD Candidate at Architectural Association, London
[2]Lecturer at Bartlett School of Architecture, University College London, United Kingdom
aimantabony@gmail.com, e.llabres-valls@ucl.ac.uk

Abstract

Current conditions related to food security lead to study alternative forms of food production in cities such as vertical urban farming in high dense urban environments. This paper discusses the development of the Innovate UK award-winning project consisting of a dynamic system model that generates a large dataset of artificial environments linked to a multi-objective optimization model of urban massing for one square kilometer of development along the coastline of Singapore. The scope of the model is to reach the highest level of self-sufficiency in relation to food consumption.

The model operates, as a dynamic system constituted of different subsystems including transport, water, agriculture and energy. These systems dynamically interact among each other and with their environment, which is considered the primary source of energy and the main provider of hydrological resources. A large dataset of artificial environments is created employing a Dynamic System Modelling Software; this includes different scenarios of environmental stress such as sea level rise, population growth or changes on the demand side. Such dataset of artificial environments serves as an input for the multi-objective optimization model that employs genetic algorithms to produce a large data set of urban massing including the distribution of a range of food production technologies in relation to pre-established conditions for vertical urban agriculture and compatibility with other urban programs. Connectivity, solar radiation and visual cones are the fitness criteria against which the model has been tested. This paper assesses whether artificial environments further away from the pareto front produce populations of urban design solutions that respond to extreme environmental conditions and environmental shocks.

Keywords: Urban Design; Ecology; Vertical Farming; Dynamic System Modelling; Evolutionary Algorithms; Relational Urban Model

1. Introduction

Food security is an urban challenge that will be exacerbated by population growth and climate change. Historically, urbanization emerged from the development of agriculture. Settlements were well embedded in their immediate environment, developing distinctive morphologies and a metabolic infrastructure that adapted to the local conditions. Currently, extensive agriculture in remote areas sources global cities. According to UN by 2050 the world population will reach 9.5 billion people, this increase of 2.5 billion requires an additional of 850 million hectares of arable land.(Alexandratos & Bruinsma, 2012; Despommier, 2009). The impossibility of taking away such quantity from other ecosystems implies to reconsidering the existing production system that is supporting our cities.

Back to the end of XIXC, when agriculture started to intensify and concentrate in remote areas a group of architects addressed food production in cities. Two seminal projects were developed at that time: (1) Frank Lloyd Wright's "Broadacre City" and (2) Ludwig Hilberseimer's "New Regional Pattern" (Hilberseimer, 1949; Wright, 1932). Both projects advocated for decentralized

and integrated agriculture within cities. Some of the principles from "The Agrarian City" could be relevant today; particularly, Hilberseimer's interdependent unit of production and its integration in the ecology of the region. Down to the scale of the technology, the ecologist Despommier argued that, with the same footprint, indoor farming techniques and controlled-environment agriculture technology could yield much more food than outdoor farming (Despommier, 2009). The liability of this technology lies in the fact that vertical farming requires much more energy due to the need of artificial lighting and climate control system. Numerous studies have been developed at the architectural scale; among these are Harvest Green Tower and Sky Farm in Canada, Plantagon in Sweden and La Tour Vivante in France.(Al-Kodmany, 2018). A large majority of these look at vertical farming as an architectural problem focusing on the relationship between architectural morphology, solar radiation, energy dynamics and the organization of the production system at the scale of the building. However, looking at vertical farming from this perspective has limitations in order to understand whether vertical farming as a production system can make a significant impact at the city scale. In order to cover this gap, it is necessary to bridge two scales, one that is related to the interrelated unit of production and its relationship with the ecology of the city along the lines described in Hilberseimer model and the other related to scale of the technology described by Despommier.

This paper aims to cover this gap by bridging the two scales mentioned above and looking at the feasibility of implementing vertical farming at the scale of the urban block. It will do so by discussing the development of the Innovate UK award-winning project consisting of a dynamic system model that generates a large dataset of artificial environments linked to a multi-objective optimization model of urban massing for one urban block in Singapore. The scope of the model is to reach the highest level of self-sufficiency in relation to food consumption.

The model operates, as a dynamic system constituted of different subsystems including water, agriculture and energy. These systems dynamically interact among each other and with their environment, which is considered the primary source of energy and the main provider of hydrological resources. A large dataset of artificial environments is created, employing a Dynamic System Modelling Software; this includes different scenarios of environmental stress such as population growth or changes on the demand side. Such dataset of artificial environments serves as an input for the multi-objective optimization model. This employs genetic algorithms to produce a large data set of urban massing including the distribution of vertical farming technologies. Solar radiation is the main fitness criteria against which the model has been tested. The integration of these two methods could increase the potential of the urban blocks to function as productive system. The experiment demonstrates that it is possible to achieve self-sufficiency by integrating vertical farming as integral part of the urban block. Five hours of sunlight at the ground level are the optimum value generated by the model.

This paper is structured in three sections: Section (1) The agrarian city in the age of planetary scale computation; discusses vertical farming as a production system building a comprehensive approach that ranges from the scale of the region to the scale of the technology. In addition, taking in consideration the city as a dynamic complex system and the socio-economic implications of what Benjamin Bratton defines the age of planetary scale computation. Section (2) introduces the design methodology consisting of three sub-sections: (2.1) The study of the technical advantages and constraints of vertical farming and how these set the principles for the urban morphology in the parametric urban model. (2.2) The use of dynamic System Modelling for the development of artificial environments in Singapore. (2.3) The use of evolutionary algorithms for the development of urban morphology linked to specific conditions defined by the artificial environments developed in section (2.2) section (3) findings and conclusion.

2. The Agrarian City in the Age of Planetary Scale Computation.

In 1990s the ecologists Dickson Despommier suggested Vertical Farming as an alternative to conventional agriculture production (Despommier, 2009). The defining feature of this technology is to increase production without additional footprint by stacking greenhouses on top of each other. Numerous attempts have been done in order to implement it in the city but the predominant production system is still based on centralization and intensification of arable land. This section discusses the potentials and drawbacks of this technology taking in consideration the socio-economic aspects as well as technical, morphological and urban constraints related to vertical farming. The aim is to define the principles of a production system that can have an impact at the city scale by looking at what is the appropriate type of urban documentation for the development of the system, the interdependent unit of production and which urban protocols, parameters and regulations are necessary in order to implement vertical farming as a production system in Singapore.

By the end of the XIXC, industrial manufacturing and the development of railway systems set the seeds for the centralization and intensification of agriculture in the countryside. Intensification started to show its negative effects including soil exploitation, resources depletion, air pollution, slums and cities' disintegration. In response to that, there were a number of ambitious urban planning projects that explicitly attempted to integrate agriculture within the city. Later named as the agrarian city, the projects focused on urban agriculture and its implication on the city form and its structure (Waldheim, 2010). One of these projects was carried out by Ludwig Hilberseimer - the decentralized city (1944) - where he proposed the principle of decentralization and integration of agriculture and industry. He argued for the region as the appropriate area for planning interference, "an interrelated part of country, a natural unit, self-contained by reasons of geographical advantages, natural resources, soil condition, natural and man-made routes, developed and used by population". In his model, the region is considered an organism in which the whole is related to the parts, and the parts related to the whole; aiming to reach a balanced production and support life (Hilberseimer, 1949).

One useful idea is that of the interrelated units of production constituting a whole. In the contemporary scenario, the units must be redefined according to site-specific conditions and taking in consideration the introduction of new technologies. Despommier's concept of vertical farming consists of stacking layers of crops under rigorously controlled conditions. This implies less required land and therefore the size of the interdependent unit of production should be smaller. Here, the interdependent unit of production is an average Singaporean urban block of 350x220 meters, 40% is considered green area and the average population is 8500 residents/block.

Other advantages of Vertical Farms technology are: (1) they use significantly less water thanks to the irrigation techniques available today (drip irrigation, aeroponics and hydroponics), (2) pesticides and herbicides are no longer needed and (3) they can efficiently recycle organic waste and wastewater (Rassia et al., 2012). The building typology of vertical farms can vary between high-rise buildings, underground spaces, facades and rooftop greenhouses. The main disadvantage of this technology is the economic feasibility in relation to the energy demand. In a scenario where the vertical farm is lit only with artificial light the energy demand is much higher than other methods of production. Therefore, the feasibility of the vertical farm relies on how much natural light and renewable energy it receives in relation to the footprint and it will be described in detail in the following section (Kalantari et al., 2017):
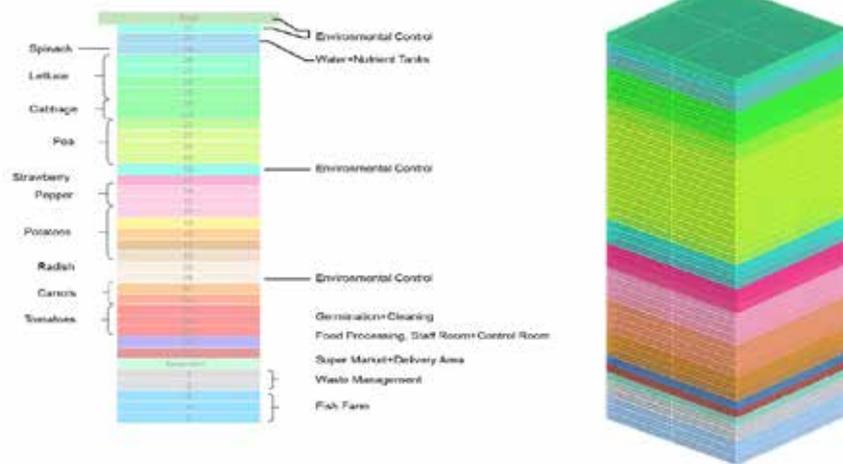
Figure 01.

Vertical farming is equipped with sensors, algorithms and actuators, which form a coherent and interdependent whole. This association between hardware and software implies that the units are best interrelated by means of digital forms of urban documentation: Relational Urban Models. According to Rico and Llabres (2012) "These are customized toolkits of urban parametric models, databases, infographics and interactive platforms allowing real time interplay with urban form in such a way that users can understand interdependencies between different spatial and non-spatial components of the projects. The purpose is not so much showcasing existing data or decisions made a priori, but fabricating new knowledge and building urban institutions understood as "a set of rules based on ethical values of a specific community that influence the individual's decision making"(Llabres & Rico, 2012). RUMs follow the principles of Benjamin Bratton's argument: the importance of the planetary scale computation and how hardware and software technology are affecting the way citizens access to products and services (Bratton, 2016). In this case, the RUMs are crucial to achieve a balanced production between the interdependent units as well as connecting the user with the production system.

Another aspect that the model aims to address is why cities are more and more reliant on food sources far away from centers of consumption: one example is how the rapid urbanization in China and the development of Megacities such as Beijing rely on extraordinary landscapes such as the Soy Plantation Expansion in Mato Grosso, Brazil. After World War II there was a drastic drop in transport cost, an increasing openness to international trade and the emergence of the knowledge-based economy. As Paul Krugman defined in his seminal book New Economic Geography, that when transport cost starts to be marginal and wages in cities increase, food production localizes more and more in remote areas were the labor cost is lower.(Fujita & Krugman, 2004). The existing scenario proves that productions systems are difficult to plan but are the result of how institutional development and advances in technology interact defining production systems that respond to an existing environment which is by definition a complex dynamic system.
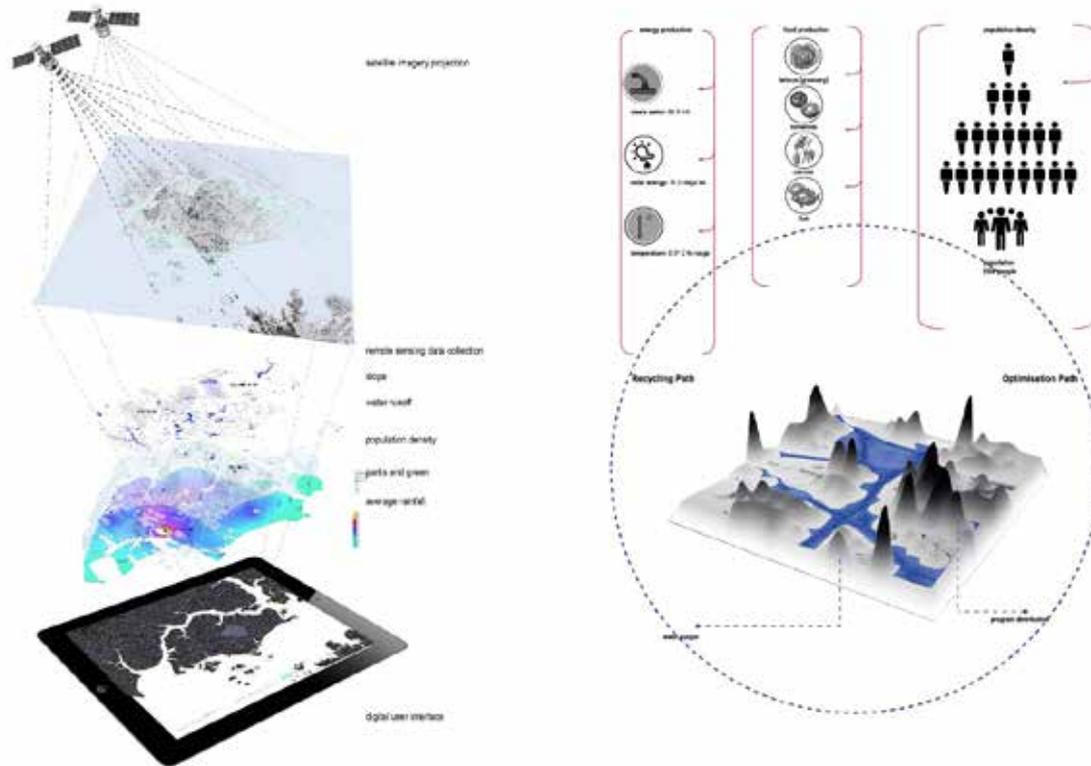
Figure 02.

Based on general system theory developed in the fifties and sixties, the notion of city as a system replaced the traditional conception of the city as physical structures and aesthetic organization. A system is composed of a set of interacting subsystems with hierarchal organization embodying feedback and keeping the system in equilibrium within its boundaries. However, city systems are more likely to be in disequilibrium or even classed as far from equilibrium (Batty, 2013). This notion exhibits the key feature of complex systems that is the dynamic evolving nature of the system itself. Thus, cities can be seen as dynamic adaptive complex systems composed of constellations of interactions, communications, flows and networks ; showing the characteristics of complex dynamic system including scaling, self-similarity and far-from-equilibrium structures (Batty, 2008). Complex systems exhibit three distinctive properties: Firstly, the complex collective behavior: the collective actions of the systems' components that give rise to the emergence of behavioral patterns of the system, commonly known by "the action of the whole is more than the sum of action of the parts". Secondly, signaling and information processing; systems and their components produce and use information from both their internal and external environments (Mitchell, 2011). Lastly, adaptation, complex systems change their behavior and strategies to adapt in response to interaction with other components through evolutionary or learning processes. These three properties, collective behavior, information processes and adaptation are the core concepts in dynamic systems modelling.

Considering the city as a dynamic complex system, places the emphasis on the continuously changing behavior over different timescale. Thus, the appropriate modelling framework is one based on Dynamic System Modelling (DSM). The (DSM) approach was developed in the fifties by Jay W. Forrester, at the MIT (Forrester, 1997). It is used for a broad spectrum of applications including modelling complex ecological and economic systems. This method simulates the system by mathematically solving the set of linear equations that describe the system (Ljung, 1998) (DSM). However, the ability to represent spatial conditions and morphology is limited because it cannot effectively describe the detailed

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distribution and situations of the spatial factors in the urban system. In order to bridge this gap, and relate the production system to the urban morphology the (DSM) is linked to a parametric design software. The purpose of linking these two modelling tools is to understand the complex dynamics both quantitative and qualitative involving the introduction of vertical farming in the city.

Overall, this section defines the principles of the model proposed in this paper. The proposed model departs from an interdependent unit of production that is defined by the site-specific conditions and the constraints of the technology, which in this case is the vertical farming. This unit is interdependent with other units using a digital form of urban documentation called Relational Urban Model. (RUM) allows real time interplay with urban form in such a way that users can understand interdependencies between different spatial and non-spatial components of the production system (Llabres & Rico, 2012). And Lastly, considering cities as dynamic adaptive complex systems, the viability of the unit is tested using a Dynamic System Model linked to a parametric design model.

3. DESIGN METHODOLOGY

The design methodology is structured in three sub-sections: (1) The study of the technical advantages and constraints of Vertical Farming and how these set the principles for the urban morphology in the parametric urban model. (2) The use of Dynamic System Modelling for the development of artificial environments in Singapore. (3) The use of Evolutionary Algorithms for the development of urban morphology linked to specific conditions defined by the artificial environments developed in section (2).

3.1 Vertical Farming: from Energy Flows to Principles for Urban Morphology

Energy flows (demand and generation) set the principles for Vertical Farming Design. This section discusses how the understanding of the energy flows can influence the design of the building morphology and the urban block. Vertical Farms need to capture light to cultivate the crops indoors and pump water throughout the building for the hydroponics. The amount of water needed for hydroponic agriculture is estimated to be 10.71 liters per square meter. Contingent on the type of crop, 200-600 liters of water is needed to provide 1 kilogram of dry product (Kalantari et al., 2017). In addition to rainwater Vertical Farms can also re-use grey water; which once filtered, it can be used for watering indoor or outdoor plants. Water is pumped to the top from which it falls down and irrigate the crops through gravity. The water that evaporates inside the farm can be used again by dehumidification. Renewable energy can be produced by distributing solar panels on the roof and on one side of the facade. ETFE (Ethylene Tetra Fluoro Ethylene) is a material with the adequate transparency and the thermal rate needed to raise the amount of sunlight needed (Kalantari et al., 2017).

Light system needs to be highly efficient for photosynthesis of plants. The light required in closed space for vegetation growth is about 18 hours a day. In addition to natural daylight, vertical farms need daylight concentration, direction and distribution strategies. During the day, much of the light energy needed for the plants to grow is reflected when touches the glass. When the light touches plants at a low angle, less light is absorbed in any square inch of the leaf. Solar energy needs can be gathered by a system of mirrors from the buildings around the city. However, in the majority of the cases, there is a need for artificial lighting too. LEDs (Light Emitting Diodes) are increasingly used as a source of light for plants. Among their advantages are, long life, energy efficiency and the capability of programming light wavelengths to better manage the photoperiod. (Al-Kodmany, 2018)

The purpose of quantifying the energy flows is to determine how much energy is needed to meet the demand and whether renewable energy can meet it. In vertical farming the dimensions and proportions of the building footprint is correlated to whether the energy demand can be met by renewable energy. The larger the footprint, the larger the lighting and water requirements but also the energy available. The opposite also applies, the smaller the footprint the lower the demand but also the amount of energy

available is reduced. Al-Chalabi (2015) studied the feasibility of the building footprint for a vertical farm 33 levels high. A vertical farm with a footprint up to 20x20 m does not require artificial lighting. Up to 23x23 m the vertical farm requires lighting but is still feasible by means of renewable energy. Between 25x25m to 30x30m footprint, the energy deficit increases exponentially: for 25m the number of solar panels required are as much as twice the amount that could be fit in the envelope, whereas for 30m the number of solar panels required is four times the amount that could fit. (Al-Chalabi, 2015)

The implementation of vertical farming at the scale of the urban block requires taking into consideration the number of sunlight that each area of the block is going to receive. The land-use at the ground floor level is divided between green landscape and built. The proportion between landscape and built follows the planning requirements in Singapore which is a minimum of 30% at the ground floor level (Urban Redevelopment Authority, 2018). The parametric model generates the volume that should not be blocked for the green space to receive a specified amount of direct solar access during a certain time of the year. This concept is the reverse of the solar envelope and allows to secure minimum hours of sunlight for the vertical farm to be self-sufficient.

3.2 Dynamic System Modeling and the Development of Artificial Environments in Singapore

As described above System Dynamic (SD) was initially introduced by Forrester in the sixties. It is a method to simulate the behavior of a complex system over time mimicking the real system. SD converts the whole system into interconnected series of stocks and flows, which interact between each other according to functional relationship. It can be implemented for different systems at various scales from local to national to global. SD is based on the following principles: 1) system boundary which is a crucial property in understanding and identifying the internal and external dynamics of a complex system. 2) Hierarchy which determines the appropriate level of model according to the purpose of the model. 3) The feedback loops principle is a modeling technique which facilitates the simulation of complex systems. 4) Stocks and flows, this principle enables to quantitively simulate processes, where stocks represent the current state of the system and are the basis for actions and change by flows.

Figure 03.

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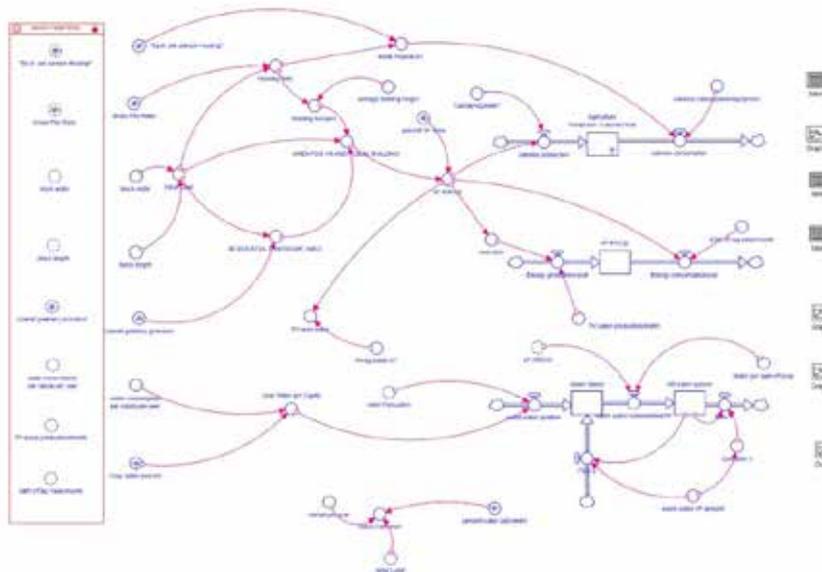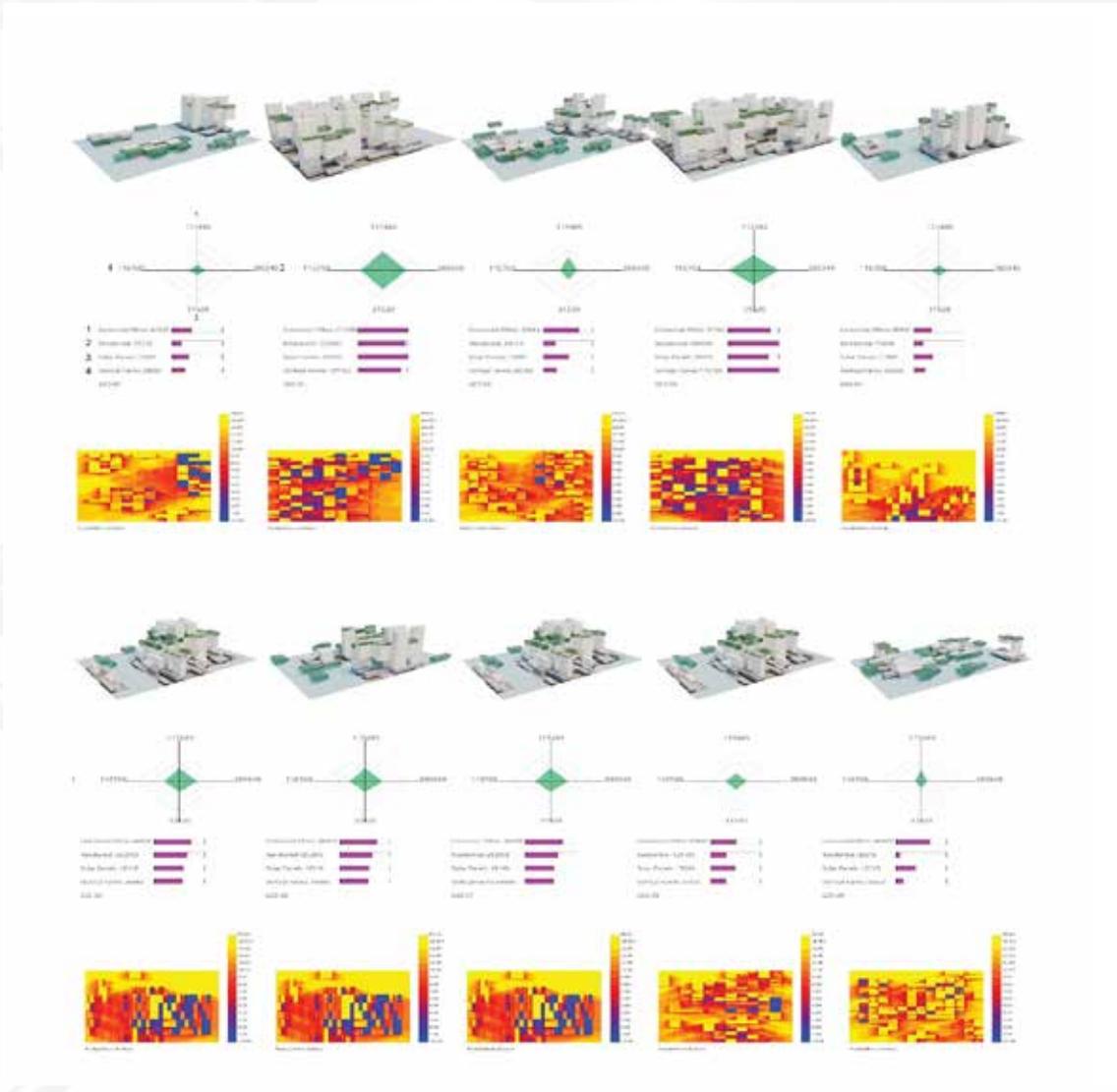
Figure 04.

The SD modeling assumes that every real system can be modeled as a system of equations describing relationship between interconnected flows and stocks. The stock flow is shown in the following equation [1]. The structure of the SD model is often broken into different aggregated sub-systems. The relationships between these sub-systems compose the whole system by a network of stocks, flows and feedback loops. Identifying and recognizing the key components and feedback loops within the system is crucial to the efficiency and accuracy of the model. The methodology of designing SD model could be concisely described in four stages (Pejić-Bach & Čerić, 2007). (1) The problem definition and articulation which addresses the values of the stocks and the processes between them are determined by the flows. (2) The model conceptualization and hypothesis formulation determine the dynamics of the system and the feedback loops. (3) The formulation of mathematical algorithms. (4) The model verification and validation enabling the testing of the dynamic hypothesis at different scenarios including sensitivity analysis and multi-objective optimization.

For the experiment developed in this paper, the purpose of the (SD) is to generate the numeric data needed as objective for the parametric design model. The initial phase of the modeling process is to define the main elements of the system: in this case, population, vertical farming, energy production

and water management. The population data is determined according to two existing parameters: (1) the maximum gross plot ratio and (2) the housing area per capita. The population and the block dimensions determine the minimum green and public space within the block. Once defined the main elements of the system, mathematical equations establish the interrelationship between these elements. The system hypotheses consist of producing enough food measured in calories for the given population and generating sufficient energy to meet the demand and reuse the wastewater for irrigation.
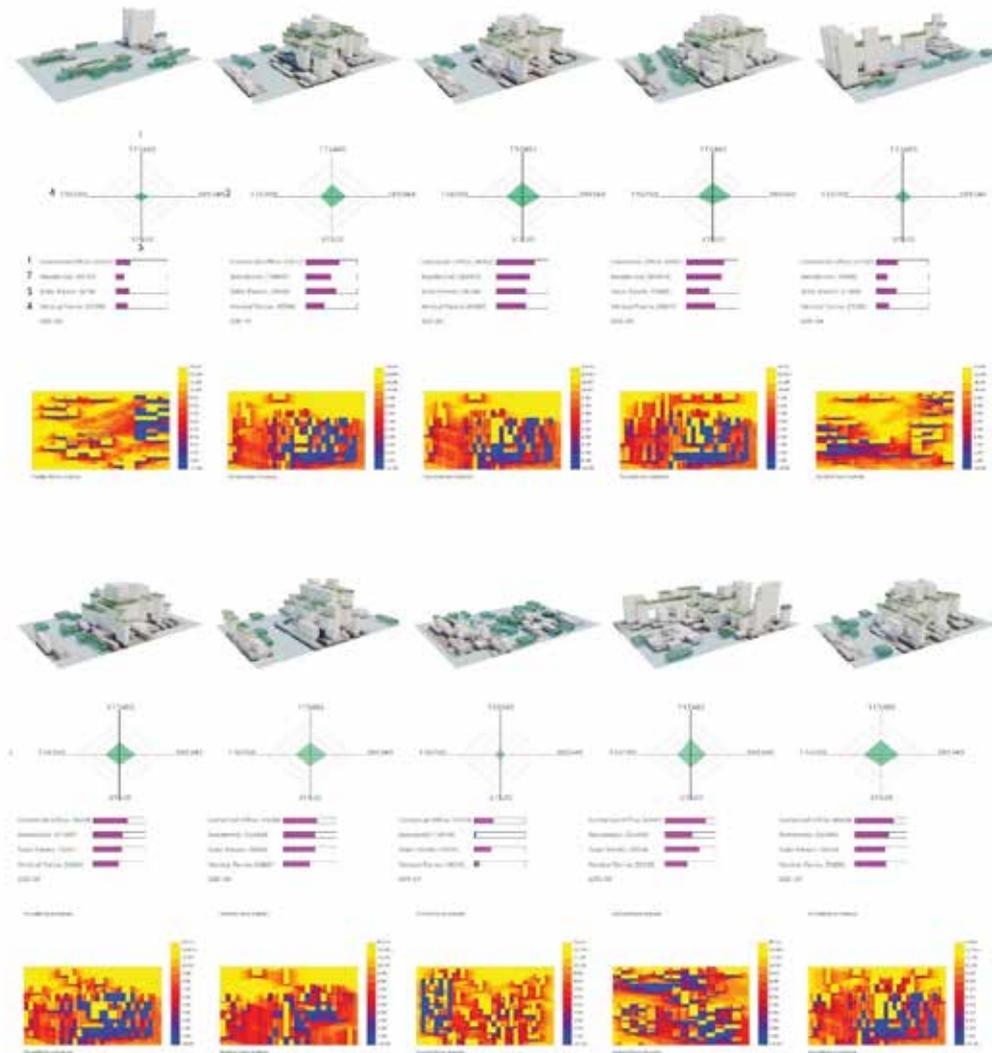
Figure 05.

One of the objectives of the experiment is to search for a set of scenarios that describe different behaviors of the system. This is conducted by employing the sensitivity analysis method. For the presented experiment, four parameters are tested against a specific value range. These parameters are: the living space per capita, the gross plot ratio, overall greenery provision and the percentage of vertical farm area from the total green area. The SD generated two hundred fifty-six solutions. Graph (02) shows the values of vertical farm production for each scenario. In the evaluation, solutions with negative value of production are eliminated because they do not meet the objective of self-sufficiency. Graph (01) shows the ratio between population and food production.

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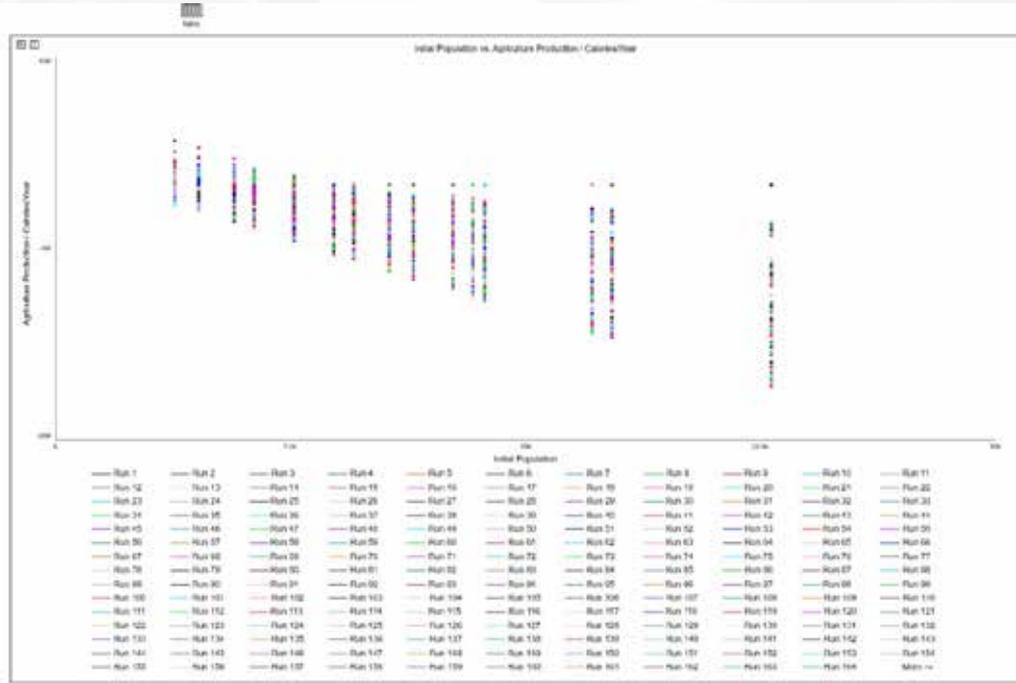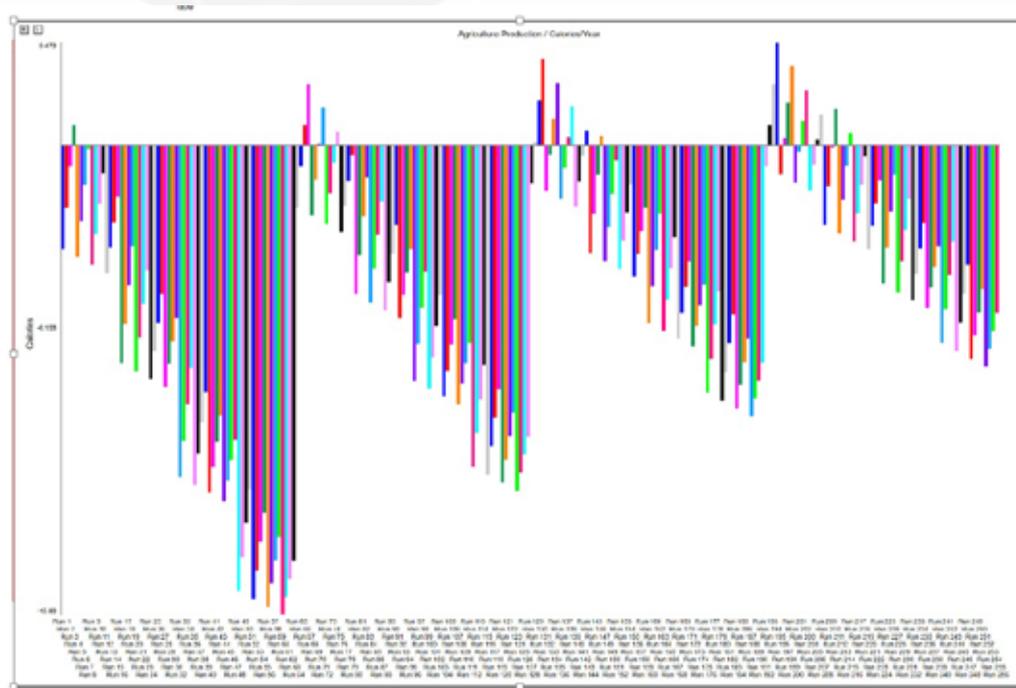
Graph 01

Graph 02

The final step is to process and evaluate the system outcomes and discuss its implications on the productivity of the system. The selected solutions comply with the following criteria: (1) Fall within the population range of 7.000-10.000 people and (2) provide enough vertical farm to be considered self-sufficient. The solution with the largest population from the selected ones were chosen as the preferred. Table (01) shows

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the values of all solutions that meet the criteria described above; the ones highlighted in yellow will be exported to the parametric design model as a criterion for optimization in order to generate urban form.

	Sq.m. per person Housing	Gross Plot Ratio	Overall greenery provision	percentage VF of Public area	Initial Population	Agriculture Production / Calories/Year
Run 1	15	1.4	0.15	0.25	7611	2773.45
Run 2	15	1.4	0.15	0.42	7611	2773.45
Run 3	15	1.4	0.15	0.58	7611	2773.45
Run 4	15	1.4	0.15	0.75	7611	2773.45
Run 145	25	2.3	0.15	0.25	7611	2275.09
Run 146	25	2.3	0.15	0.42	7611	2275.09
Run 147	25	2.3	0.15	0.58	7611	2275.09
Run 148	25	2.3	0.15	0.75	7611	2275.09
Run 5	15	1.4	0.25	0.25	7611	1705.54
Run 6	15	1.4	0.25	0.42	7611	1705.54
Run 7	15	1.4	0.25	0.58	7611	1705.54
Run 8	15	1.4	0.25	0.75	7611	1705.54
Run 149	25	2.3	0.25	0.25	7611	1207.18
Run 150	25	2.3	0.25	0.42	7611	1207.18
Run 151	25	2.3	0.25	0.58	7611	1207.18
Run 152	25	2.3	0.25	0.75	7611	1207.18
Run 9	15	1.4	0.35	0.25	7611	637.62
Run 10	15	1.4	0.35	0.42	7611	637.62
Run 11	15	1.4	0.35	0.58	7611	637.62
Run 12	15	1.4	0.35	0.75	7611	637.62
Run 153	25	2.3	0.35	0.25	7611	139.26
Run 154	25	2.3	0.35	0.42	7611	139.26
Run 155	25	2.3	0.35	0.58	7611	139.26
Run 156	25	2.3	0.35	0.75	7611	139.26
Run 225	30	3.3	0.15	0.25	8880	850.69
Run 226	30	3.3	0.15	0.42	8880	850.69
Run 227	30	3.3	0.15	0.58	8880	850.69
Run 228	30	3.3	0.15	0.75	8880	850.69
Run 81	20	2.3	0.15	0.25	9514	886.02
Run 82	20	2.3	0.15	0.42	9514	886.02
Run 83	20	2.3	0.15	0.58	9514	886.02
Run 84	20	2.3	0.15	0.75	9514	886.02

4. Multi-Objective Optimization Model

The second step of the experiment is to generate a population of urban block morphologies based on the DS output data. The aim of the experiment is to generate the fittest solution using an evolutionary algorithm towards multiple conflicting objectives. The evolutionary algorithm behind the solver is the Strength Pareto Evolutionary Algorithm 2 (SPEA2), which mimics a natural evolution including variation and selection strategies, which are applied to a population. The algorithm evaluates and select a set of candidate solutions in each generation, and the parameters that were set in the solver are (1) number of generation (iteration):10. (2) Number of individuals in each generation: 1.0 (3) Crossover rate: 0.8. (4) Elitism: 0.5. (5) Mutation Probability: 0.2. (6) Mutation rate: 0.9.

The model departs from the urban block (350X233 meters). The allocation of urban massing follows the principles of solar radiation, allowing a minimum hour of solar exposure of the green areas at the ground level. The multi-criteria for optimization are: 1) maximizing vertical farming area, to achieve higher productivity 2) maximizing the green area, to provide public and social space 3) maximizing residential buildings area 4) maximizing distance between building clusters, thus increasing the area of open space between the buildings. These objectives are contradictory because they all compete to occupy more area of the block.

When the transformation actions on the block are defined, there is a direct correlation between them and the fitness objectives. For the evolutionary algorithm, these actions are the genome of the model that define the genetic code of the evolutionary process. The actions are as follows: 1) the height of the vertical farms, 2) the footprint in percentage of the vertical farms related to the green area 3) the size of the unit 4) the percentage of the build area, and 5) the average hours of sunlight exposure on the green area and vertical farms. The parametric model was defined to allow the development of vertical farms at the ground level and on the rooftops and balconies.

5. Findings and Analysis

The simulation generates 10 generation with 10 solutions (individuals), three generation are chosen for analysis. The analysis of the morphology of each solution is carried on by two methods, visually and quantitively. The quantitively analysis is a key factor in determining the selection of the optimal solutions. Algorithm was run on each selected solution to generate a quantitative data. The data extracted are: 1) The total area of vertical farming. 2) The total area of solar panels. 3) The total area of residential buildings. 4) Solar radiation. The analysis aims to identify the solution that falls in the criteria that was generated by the DS simulation.

From the analysis, it is apparent that in generation 3 there was a wide variation within the population; the results were notably different. Three solutions meet the initial quantitative objectives, but the morphology evolved towards clustering most of the building in one cluster. Therefore, all the solutions in this generation were dismissed. In generation 6, the solutions evolved in lesser variation than in generation 3. In some solutions, value of the residential was too low, for example, solution G6-07 has the lowest value for residential area of all the generation. In this generation, there are the largest fittest number of solutions, six in number. However, the one with the highest values within the objective range and greater number of clusters was number G6-08. This solution was selected as the fittest. Lastly, generation 09: the convergence tendency within the population increased and the results were closed. The three fittest solutions were the closet to the SD objectives, in terms of morphology just one solution fit the clustering objective. Solution number G9-08 was selected. The analysis process results in selecting 2 solutions for further design development and modifications solution G05-08 and G09-05. The model determined the number of hours of sunlight required at the ground level is 5 hours.

Objective	DS Values	G03	G05-08	G09-05
Housing Area	190283	-----	204435	180185
Vertical Farms Area	44900	-----	502954	45370
Solar Panels Area	8100	----	50236	18926
Number of hours of sunlight	5	5	5	5

6. Conclusion

The experiment shows the advantages of integrating two modeling methods in the urban design process, namely the DS modeling and the parametric design model. The DS model generates multiple scenarios of artificial environments in Singapore according to sensitivity analysis. While the parametric design model generates a set of optimized solutions to fit the performance of the urban systems. The integration of these two methods could increase the potential of the urban blocks to function as a productive system. The experiment demonstrates that it is possible to achieve self-sufficiency by integrating vertical farming as integral part of the urban block. Five hours of sunlight at the ground level are the optimum value generated by the model. The presented model is based on general data, estimations and limited number of generations in evolutionary computation. The more detailed the DS model the closer to the real system. Increasing the amount of the generation and size of the population in the evolutionary process could increase the convergence to the fittest solution.

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Smart Interactive Buildings [SIBs]:
The use of Ambient Intelligent Systems [AMIS] to Enable Smart Interactive Settlements [SISs]

Mahmoud Al Saeed[1]; Fodil Fadli[2]

[1,2]Department of Architecture and Urban Planning, College of Engineering,

Qatar University, Qatar

f.fadli@qu.edu.qa

Abstract

The 21st Century is witnessing the dawn of Industry [I4.0], or the fourth Industrial Revolution. With burgeoning technological inventions linked to smart interactive cities and intelligent buildings, where humans-machines-spaces interact continuously.

Our ambition in this explorative study is to design and develop a sophisticated interactive computational platform that interacts and responds to humans' [users] needs and aspirations, which are increasing exponentially, in complete synchronization with machines, spaces and buildings' capacities. Consequently, there is a demand and necessity to develop Ambient Intelligent Systems (AMIS) which enable the creation of intelligent settlements that efficiently ease the communication between users/ users, users/machines and users/buildings. This is importantly needed in order to reduce the ascending consumption rate of energy in an integrative design manner.

The aim of this study is to investigate the current technological solutions that address the subject of human/buildings [includes machines and spaces] interaction through sensory devices and computational systems. This can be achieved through the design and development of a comprehensive understanding of the human/buildings interactions, in the form of Ambient Intelligent Systems that enable the interaction of different stakeholders and users with the building they live/work in, at real-time. This will solve any problem related to energy usage and hence environmental quality control indoor-outdoor of the building.

The findings of this study demonstrate the necessity of integrating AMIS solutions into the early stages of buildings design as a primary method of Design, Build and Operation (DBO). Earlier computational design technologies would help develop an Advanced Design, Analysis and Management System (ADAMS). This system has been simulated and validated effectively to enable human-buildings constant interactivity at all time in real-time reaction. AMIS solutions through ADAMS model lead us as designers, architects, planners and users to consider our buildings as an interactive living entity rather than a static conventional mass. Humans-Buildings-Spaces interaction through AMIS platforms will be capable of collecting, analyzing, synthesizing and developing adequate customized decisions at their own, as Artificially Intelligent [AI] constituents of the Smart Interactive Buildings [SIBs] network, which would undoubtedly lead to reduced energy consumption and healthier livable Smart Interactive Settlements [SISs].

Keywords: Ambient Intelligent Systems [AMIS]; Smart Interactive Settlements [SISs]; Smart Interactive Buildings [SIBs].

1. Introduction

Today cities obtain a great power to attract population, this power presented in the variety of economic opportunities and amenities has driven more than 50 % of world population to live in urbanized settlements where this shift expected to reach 60 % in 2030. Although urbanized areas provide better

live opportunities, yet side effects come along with population shift such as depletion of the natural resource mainly water, energy, and increased greenhouses emissions leading to damage of the natural environment and decreased inhabitant quality of life.

According to the International Energy Agency (IEA), the total energy consumed in 2003 has reached more than 106,996 TWh/y (annual consumption of energy estimated by terawatt per hour), which augmented in 2016 to 125,500 TWh/y, simultaneously our cities consume 4 trillion cubic meters of energy per year, where the buildings sector alone is accounted for 35 % of total energy consumption and 26 % of the total water consumed (IEA, 2016). At the same time today technology has become more sophisticated, intelligent and objective, the applications of "smart" technology plays an important role in the process of Design Built and Operation (DBO) of our buildings, neighborhoods and cities, where the use of "intelligent" computational technology has proven its capacity to reduce the energy and water consumption in buildings up to 30-80 % (based on the level of technology integration) (Fadli & Saeed, 2018).

With that in mind, the conventional concepts of cities as the total of built and open spaces with its supporting infrastructure, is no longer enough to define cities and solve their emerged issues. Thus, the use and integration of Ambient Intelligent Systems (AMIS) with building design, operation and management method is the future of building and energy management systems that increase the interaction between users and their environment to reach the goals of sustainable design and enhance the quality of life.

The aim of this study is to investigate current technological solutions that address the increasing demand of energy and water, along with human-buildings interaction and relationships, to develop comprehensive solutions that uses the Ambient Intelligent System [AIMs] as intelligent management platforms. This will solve any problem related to energy usage and hence environmental quality control indoor-outdoor of the building.

In order to achieve this, the authors of this study have conducted thorough critical analysis of the existing literature related to the subject of water and energy management systems with its delivery structures, along with the subjects of smart cities, like the concepts of the Internet of Things [IoT] and, Building Information Modeling (BIM), where the analysis of the previous study paves the way to construct a systemic intelligent management and monitoring platform, that opens the doors for further development in water-energy management systems. Ideally, to the resolution of the issues of resource bleeding and human- building interaction.

The findings of this study demonstrate the importance of integrating computational technology solutions into the processes of building Design, Built and, Operation (DBO), to address the existing issues and those predicted of the increasing demand on energy and water along with the issue of building and user's interaction. The findings of this study form the foundation of the Advanced Design, Analysis and Management System (ADAMS) as fully integrated, with intelligent management and operation platform, hence leading to the resolution of investigating issues of water, energy and, management systems (Fadli & Saeed, 2019; Boguslawski et al., 2015).

2. Conceptual Framework

Beyond doubt, the issues of increasing consumption rate of energy and water are rising every year with no clear systemic method or solutions leading to decrease in the quality of life and increase in the natural environment threats and challenges.

The conceptual framework of this study works on integrating theories of practice with actual practice techniques to create an intelligent tool (Advanced Design, Analysis and Management System -

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platform) that is efficient and reliable to carry out designs, simulations, and calculate the accurate needs of energy and water, Moreover to predict the possible issues, along with a simple yet intelligent and effective management tool – that increases the interaction between users and buildings.

In that sense the authors have divided this study into three phases, starting by identifying the core concepts of the subjects of Smart Interactive Building (SIB's), water and energy management system, Ambient Intelligent Systems Applications as well, where the finding has been merged together to formulate a group of recommendations and create the Advanced Design, Analysis and Management System (ADAMS) (Figure 01).
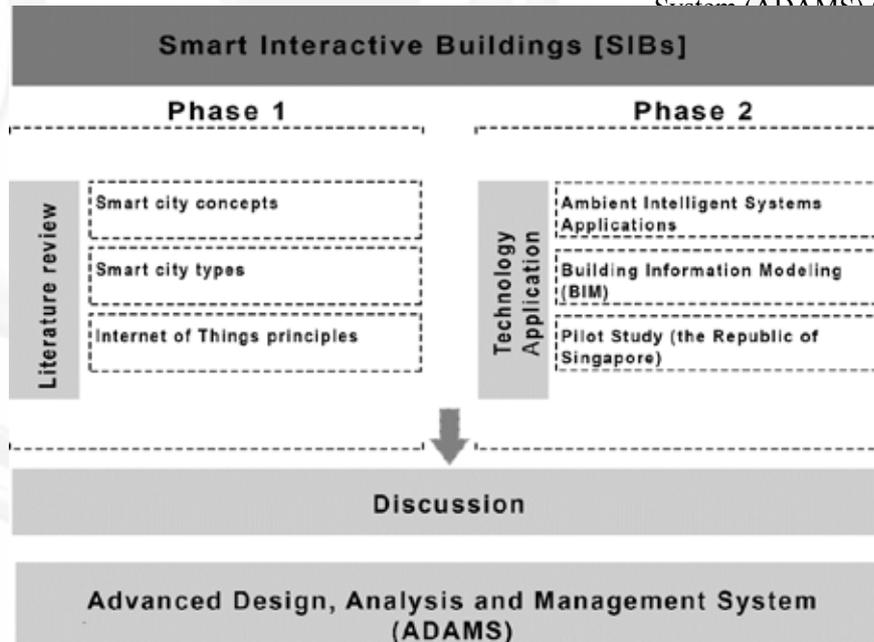
Figure 01: Schematic development diagram of the conceptual framework.

3. Background Developments

This section investigates existing knowledge of the subject of smart cities, and technology applications in the process of building, energy and water management systems. Moreover, a pilot study was conducted to explore and highlight over what the current attempt has done to the resolution of the identified issues.

3.1 The "Smart City" Concept

The city that has the ability to collect, analyze and react towards information in a spatial context is considered as a "smart city". Although the concept of smart cities is relatively new, yet it succeeds to attract more attention among scholars and practitioners. The definition of smart city includes the aspects of several engineering fields such as communication technology, infrastructure planning, urban planning, and environmental design along with none engineering fields like economic, social and management methods. In that sense the smart city is the interaction and integration between environment and users through the physical infrastructure such as sensory systems and interaction system, at the same time, it's a communication method between objects and people (Harrison et al., 2010).

Scholars have identified several types of smart cities based on the method of the level of operation and interaction, where the most common types are the cities that depend and intensively use the applications of technology. Figure 2 lists and identifies the most common types of smart cities and their method of operation (Cocchia, 2014).
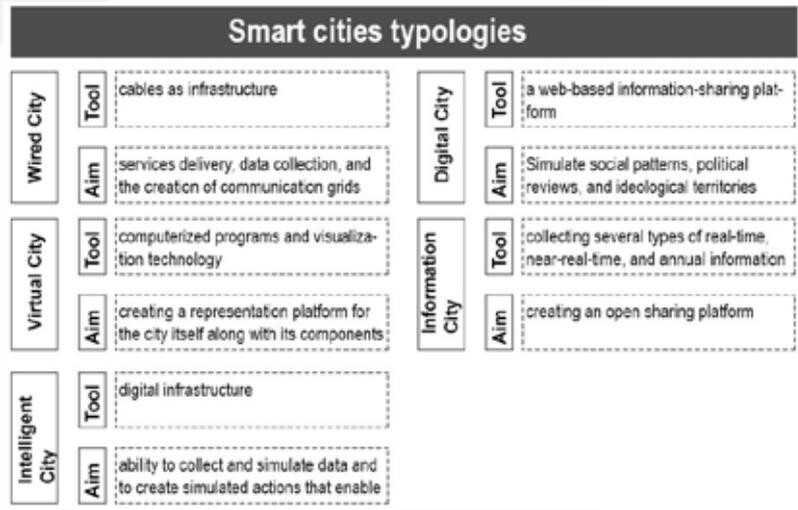
Figure 2: Smart city typologies deciphering (Saeed & Fadli, 2018 adapted from Cocchia, 2014).

The process of creating smart cities requires a deep integration between the physical (users and buildings) and none physical components (technology and programs) to establish intelligent and interactive techniques with integrated capacity to design, simulate and analyze the information generated from the city components and users (Figure 3).
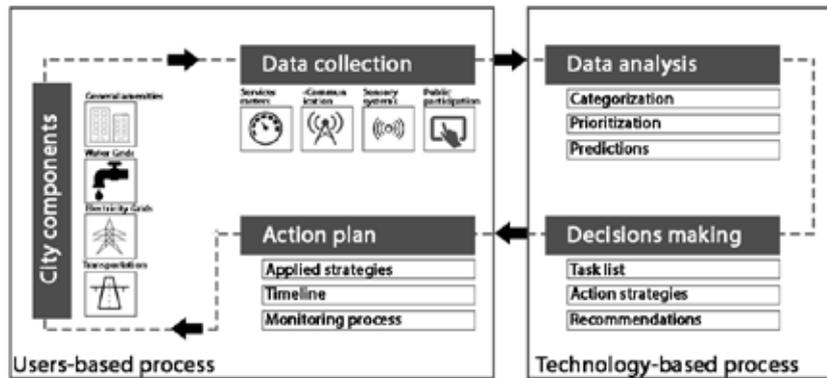
Figure 3: Smart city operational framework (Saeed & Fadli, 2018).

3.2 Internet of Things: Principles and Applications

Generally speaking, Internet of Things (IoT) concept describes the uses and applications of smart devices as multitasking tools that obtain a great capacity to communicate, collect and transfer several types of raw information's such as (weather conditions, geographical locations, consumption behaviors and, social patterns) to dedicated sharing platform (as human- buildings interactions platforms), and works as secondary information collectors as well.

The benefits of adapting IoT concepts comes from the possibility to track and record the information's in real-time with spatial context labeling and allowing the ambient intelligent systems (such as a computerized program) to categorize and analyze data, generating actual and predicting scenarios that support decision making and promote real-time interaction. Figure 4 below describes the type of interaction and the IoT method of operation. (Dohr et al., 2010; Zanella et al., 2014).
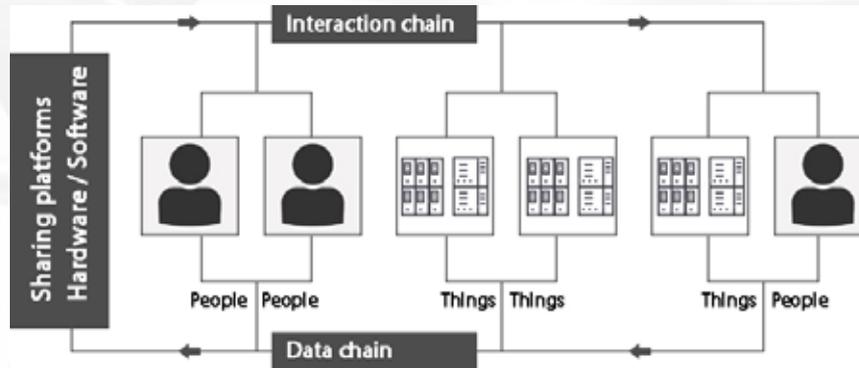
Figure 4: Internet of Things (IoT) systemic applications.

Adapting the concepts and method of IoT is vital to create smart cities, where integration of multi-tasking smart devices used as daily life tools forms the efficient and sustainable way instead of planting and integrating dedicated sensory systems where using this type of devices is extremely expensive and considered as an unnecessary cost.

3.3 Ambient Intelligent Systems Applications

Generating designs by the conventional methods requires a considerable amount of effort and costs, at the same time the conventional methods of designs miss the opportunity to predict the issues that might occur during the construction. Meanwhile, today technology (computer programs) is much more than mathematical equations and operation matrix, where today computational programs obtain a great level of intelligence to simulate and generate future scenarios and even propose different methods to face such challenges (Fadli et al., 2015; AlSaaed, 2018).

The current computer programs for design and monitoring can be easily classified into three main classes (Figure 5) based on the type of use and level of complexity, where it starts by the individual building to the group of building and finally to the scale of cities (AlSaaed, 2018).
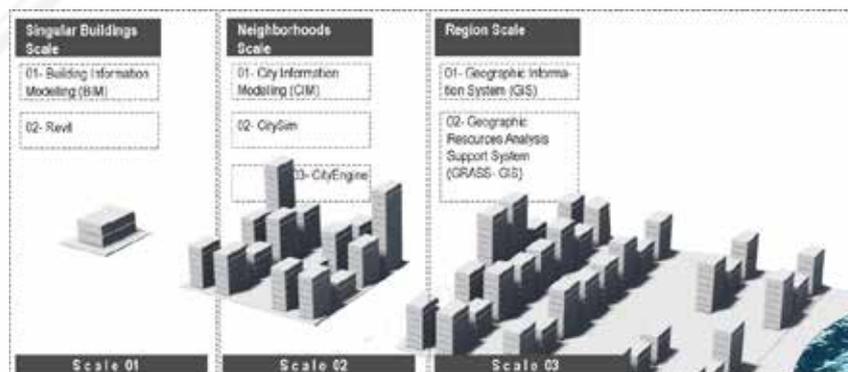
Figure 5: Program classification (Fadli & Saeed, 2018).

Building Information Modeling (BIM): is one of the direct applicators of AMIS. BIM is a computerized program that uses technology and simulation tools for design, construction, and facility management, aiming to translate the 2D information's into three-dimensional interactive platform by overlapping all design data together. The program defines the construction into three main categories that includes (Eastman et al., 2011) (Figure 6):

- Construction components: which in total forms the spaces and finally the buildings itself.
- Design data: it's the information that forms the design which in general describes the building method of operation and users' behaviors

- Coordination data: it is the collaboration between building component with buildings system and the data generated from monitoring the building systems' functions.
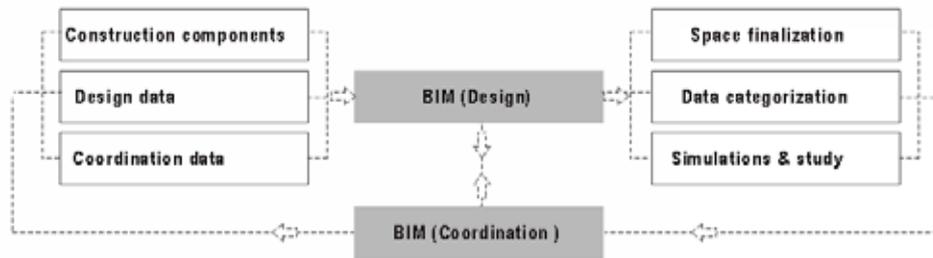
Figure 6: BIM operation method.

Case Study (the Republic of Singapore)

Described as one of the densest populated islands in the world, Singapore has a population of 5.5 million, allocated on 597 km^2 (Figure 7), where the population is composed of different races such as Chinese, Malays, Indians, and Eurasians as well (SDS, 2014). Its geographical location near to equator gives it a consistent hot and humid weather. The island of Singapore has very limited resource, where it has no energy deposits, no large forest, and even the agricultural land is very limited (CfC , 2015) despite all the geographical challenges, Singapore has grown to one of the most advanced countries in the world. The economy is fully dependent on financial service, oil revenues and manufacturing.

Figure 7: City of Singapore, Republic of Singapore (Fadli & Saeed, 2018)

Responding to the growing challenges of population boom, environmental degradation and resource bleeding (mainly energy and water); the Singapore Government took action. This consisted of Singapore Government Smart Nation (SGSN) vision that seeks to integrate the modern concepts of communication technology, information technology, and data collection strategies in order to develop the nation 'living lab' initiative that supports the human quality of life and open new field for smart solutions implementation (Ke & Wei, 2004; Komninos, 2009).

3.4 Systems Configuration

Singapore's experience of transferring the infrastructure to fully intelligent services, was developed at stages, where the huge amount of data collected is distributed on several databases, control centers and intelligent applications, with the aim to integrate all government agencies together, and bring the inhabitant closer to the services provided by government as well, the configuration of various systems includes the following process (Keon et al., 2016):

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***01- Physical systems integration*:** Integrating the urban sector (urban mobility, logistic and environment), industry sector (manufacturing and manpower), and smart platforms (operating systems and communication network and sensory infrastructure) all together to work continually with each other, the heart of the physical integration is operated and monitored through (Leonard, 2014; Intermediary, 2014):

- *Sensor management*: where both video and non-video sensors collect the data and send it to the filed facilities, to be classified and monitored according to their function and type a constancy and real time assessment method applies according to the data type (information, activation, configuration data, and so on).

- *Data exchange*: the collected, and classified information distributed into a unified sharing platform that is available and secure all the time, a group of security policies and open standards protocols apply to make sure the important data is safe and open for all government agencies and users together.

- *Sense-making platform*: the purpose of the integrated platforms is to process the data that is relevant to requested information, in other words the sensing platforms are the core of the intelligent process that give life to the user interface technology.

***02- Control centers integration*:** the distributed command centers in the city of Singapore work in parallel at two different layers, where each command center is operated by its responsible agency – like the transportation command center is run and maintained by the transportation authority, therefore there is no threat of major failure, meanwhile all the centers report to main control and management database making the information sharing available at real-time and accessed in any command center (Keon et al. 2016). The reason to create several operating centers is to cut the cost of operation, where some of the services require 24/7 through the year monitoring (such as security, citizen public health and so on) and other centers require annual inspections and checkup only.

03- Operative systems integration: the operative systems are the tools to collect and store the information where it has a secure connection to command centers, and where all the readings and information are stored classified and analyzed, the operative systems or the filed sensing systems includes (Keon et al., 2016; Urban Environmental Management, 2015; Kiat, 2016).

4. Discussions and findings

The conventional methods of urban planning maintained its rigid form for long time, although its principles are important and reliable, but it is not sufficient in keeping up with the challenges of current century and need emerged by environmental, social, and cultural changes. Hence, the necessity of harvesting the benefit of technology is increasing and today planning authorities must act in order to achieve a better understanding and adoption of technology and intelligent planning methods specifically artificial intelligence powered by man-machine interaction. The noticeable improvement of [AI] software's have proven their capacity and important role to support and enhance the process of design, leading to effective responsible and reliable designs. Yet the limitation of coordination is obvious and can't be overlooked, where almost all of design software's work at individual level and mismatching and coordination between the results almost absent.

Planning vision for future cities and enhancing existing cities needs to meet smart city requirements and methods of operation, where it should be included from the early stages of planning and design. Designs and planning is a multi-stage action, therefore technology and computerized applications shall respond to the needs of designers and planners, at the same time there are increasing demands on providing smart softwares that understand the planning process and characteristics and respond to real-time design variables.

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The increasing demand on the resources (energy and water) can't be overlooked, in parallel intelligent softwares have significantly developed with a great capacity to collect, simulate and analyze data, hence planning authorities must adopt a real-time analysis and simulation programs to allocate and predict the issues before it occurs, and channel the correct amount of resources where it is required..

5. Advanced Design, Analysis and Management System (ADAMS)

By revisiting the reviewed works of literature on this research along with the discussion built, the aim is to shape and create a tool (that possesses several abilities) to build a bridge between theoretical discussions of urban planning, design, smart city concepts, and technology applications, the creation of a comprehensive software with the ability of self-operating, monitoring which is interactive, with its users, not only as operation software but as a design application as well.

The proposed application; Advanced Design, Analysis & Management System (ADAMS) has been built into three main functions that include design process, institutional operation, and resource management, each function having several aims and sub-abilities (Figure 8), where all the functions are merged together by using web sharing platforms (clouded platforms).
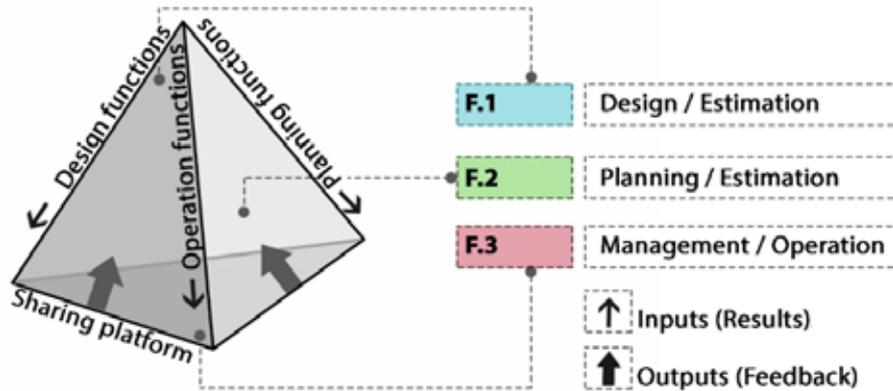
Figure 8: ADAMS main functions (source: Authors, 2018)

ADAMS' proposed method of operation works simultaneously to coordinate the outputs between designer, users, and authorities. This coordination process aims to generate responsible designs with high ability of coordination prior and after construction, the general method of operation is based on the main function provided by ADAMS as follows (see Figures 9 and 10):

- Design function: used by individuals and consultancy firms to prepare architectural drawings, electrical designs and mechanical systems, based on interactive programs method. The added values of ADAMS is the possibility to generate simulation and analysis that is compared and matched with local standards and regulation to foster the approvals and construction process, saving time and cost, ensuring that designs are accurate that provides actual need of the building eliminating the waste in energy and water consumption by using the simulation and prediction technology.

- Authorities function: dedicated to planning institutions and governmental agencies that are in charge of planning, providing and managing the infrastructure such as water and electricity, the main purpose of this function is to generate overall consumption standards and in its focused capacity provide specific regulation and standard for each plot. At the same time the ability of this tool includes integration into built city fabric at the individual level (buildings scale), to monitor in real-time the consumption and behavior readings, which analyzed and transferred into action to prevent unwanted resource consumption.

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- Operation & Management function: the wide adaption of Building Management System (BMS), which can be described as the building brain. ADAMS works on integrating the individual BMS's into one platform under authority monitoring to notification building users about their consumption rate and behaviors of consumption in real-time.

Figure 9: ADAMS main interface (Saeed & Fadli, 2018).

Figure 10: ADAMS design tool interface (Saeed & Fadli, 2018).

To date, however, technology has been used primarily to organize administrative tasks and collect information rather than to manage resources and holistically formulate urban forms. Integrating the applications of computational technology with the best-practiced methods in energy and water design, planning and operation leads to reduction in the unnecessary usage of resources; increase in the estimations and consumption efficacy of energy and water, along with the creation of functional

systematic procedures that are clear and helpful in closing the gap between users and urban structures. The created computational system obtains the essential abilities of design estimation with a high accuracy of prediction, planning principles, and operation and management methods, which leads directly to reducing the consumption of energy and water at the scale of buildings, then neighborhoods and finally the city scale.

Moreover, the system serve as real-time tracking, analysis and management platform which undoubtedly lead to reduced energy consumption and healthier livable smart interactive settlements. The findings of this study pave the way for future opportunity to develop more interactive sophisticated platforms and computerized program that work to the resolution of current and futures issues.

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Smart Cities: A Socio-Technical Perspective

Nimish Biloria

Faculty of Design, Architecture and Building

University of Technology Sydney, Australia

Nimish.Biloria@uts.edu.au

Abstract

This research paper elaborates upon the concept of Smart Cities and the evolution of the term itself throughout history in order to outline the emergence of two distinct schools of thought: technocentric and humancentric, which have shaped smart cities. The paper also categorizes smart cities based on these two perspectives and outlines the operational tactics associated with them. After discussing and summarizing the pros and cons of both perspectives, the viewpoint of a socio-technical system-based model for conceptualizing and re-thinking the smart city narrative is presented. This People, Activity, Context and Technology (PACT) based socio-technical ecosystem model and the manner in which it can overcome the shortcomings of the technocentric and the humancentric modes of thinking is thus presented as a way to understand the city and as a laboratory for initiating an ecology of informed smart innovations.

Keywords: Smart cities; Socio-technical system; Architecture; Built Environment; People-centric.

1. Introduction

Cities as agglomerates of quintessential services, cultural mix, job opportunities and prosperity have already attracted 55% of the global population to inhabit them. This figure is expected to touch the 68% mark by 2050 (UN, 2018), equating almost 6.5 billion of the expected 10 billion people in the world to be lured by the future which our cities portray. On a weekly basis, almost 3 million people globally move from rural to urban areas in search of better economic opportunities (UNDP, 2009) (International Organization for Migration, 2015). Statistically speaking, we can categorize the percentage of urbanized areas in the world as follows: Europe - 74%, North America - 82%, Latin America and the Caribbean - 81%, Africa - 43%, Asia - 50%, and Oceania - 68% (UN, 2018). This trait can also be seen if one compares the rise of the mega-city with a population of over 10 million - from 2 Mega-Cities in the 1950's to 30 Mega-Cities today and an expected 43 Mega-Cities to be established by the year 2030 (The Economist, 2015). However, this tendency to pursue a prospective future and the rampant pace of urbanization apart from contributing to 75% of global GDP predominantly by large cities (McKinsey, 2016) are also responsible for consuming 64% of global energy production and the production of 70% of global greenhouse gas emissions in 2013 alone (IEA, 2016). Globally, impacts of our increasing desire to populate, consume and irresponsibly build are becoming apparent more than ever.

According to the United Nations, climate change related disasters have increased by 2.5 times in the last 20 years (World Economic Forum, 2018). Additionally, between 1988 to 2017, 77% of the direct losses of $2.9 trillion is directly associated to extreme weather conditions owing to global warming (UN Office for Disaster Risk Reduction, 2018). At the pollution front, a staggering 4 billion tons of garbage is dumped in the ocean every year with plastic being the major constituent at 8 million tons (National Geographic, 2015), which, alone is responsible for almost 13-billion-dollar worth damage to the marine ecosystem annually (United Nations, 2014). Furthermore, to navigate our cities and owing to the lack of focused investment as well as political will, our increasing reliability on private modes of transportation results in added congestion and pollution, which, alone is responsible for 4.2 million

deaths annually due to exposure to ambient air pollution (World Health Organization, 2016). With over 80% of urban residents exposed to air pollution levels that exceed WHO limits (United Nations, 2016), living healthy is certainly under question. Not surprisingly, *The Economist*, via its Change in Livability score from 2007-2017 has reported that 'Livability' has decreased in some 98 of 140 cities (The Economist, 2017). Attributes of contemporary cities such as air pollution, noise, social isolation, crime and public safety, inactivity, prolonged sitting in work environments, and unhealthy diet owing to an overburdened life style are not only responsible for enhanced mental stress but have physiological ramifications in the form of increasing potential for stroke, heart attack, chronic respiratory diseases, diabetes, as well as cardiovascular diseases. A direct association between urban planning decisions and such drastic health risks can thus be established. For instance, in Europe as opposed to North America, integrated approaches to zoning with respect to accessibility and mixed-use development of housing, schools, clinics, shopping, businesses, etc. results in reduced use of private modes of transportation and increased appetite for active mobility and use of public transport (World Health Organization, 2018).

Cities themselves have evolved overtime and with the rise of technology have started experimenting with fusing the two counterparts of contemporary cities: the physical and the digital. This fusion is essential in order to collect and analyze multitude of pertinent data-sets associated with the city's operation, conduct rigorous analysis in order to find streamlined people-centric solutions to enhance livability, as well as to predict future scenarios of social, spatial, economic and environmental value thus enabling us to make informed urban planning decisions. This transition from purely analogue modes of conceiving and imposing decisions guiding a city's growth is now slowly giving way to adhering modes of digital governance, which thrive on the synthesis of bottom-up heterogeneous datasets in order to understand the city. This transition towards integrating technology within the built environment, in addition to improving city planning processes, has led to rendering focus on aspects of health, livability, wellbeing, ethics, and responsiveness, all characteristics of transitioning towards a smart city.

The premise for the term 'Smart City' was already laid back in the early 90s wherein the concept of Digital Cities, Virtual Cities, 2D and 3D cities, etc. was being discussed and experimented upon in various design institutes globally as a result of the advent of ICT (Nicos & Luca, 2018). In this paper, a critical understanding of Smart Cities from the perspective of socio-technical systems will be presented. This sketch of the Smart City shall first elaborate upon what a 'Smart City' is and how the term has been interpreted through time, we shall then categorize smart cities into three generations and will understand the operational trends which activate smart cities, and we shall subsequently speculate on a socio-technical model for developing responsive smart cities.

2. Theoretical Underpinnings

What is a Smart City?

According to 'Bee Smart City', a leading global smart city network and community, the Smart City concept describes the ability for utilizing the capacity of a city/community to create and adopt solutions for overcoming challenges and seizing opportunities that help transform the place we call home to a prosperous and more livable place for all stakeholders (Bee Smart City, 2017). Interestingly, this is one of the few definitions which presents an unbiased view of the terminology, which, is otherwise contesting between two predominant visions of the city: technocentric perspective vs a humancentric perspective. These two perspectives are the key to understanding how top-down as opposed to bottom-up urban planning scenarios as well as the notion of collective intelligence as opposed to data-driven intelligence confront each other, which primarily resulted in the development of a corporate smart city model popularized by IBM as opposed to a holistic smart city model thinking propelled by the European school of thought.

Kominos and Mora (2018), in their article Exploring the Big picture of Smart City Research, have presented a concise outline of the genesis of the Smart Cities. A clear distinction of two periods: late 80's till the late 90s and 2000 till 2010 and ongoing can be traced here. The second half of the 80s was steeped in innovation led development of cities, which popularized the terms 'Intelligent City' and 'Smart City'. Influential authors such as Lipman, Sugarman, & Cushman (1986) and Newstead (1989) in the late 80s followed by Batty (M Batty, 1990) and Masser (Masser, 1990) in the 90s professed about the use of IT and Networked systems for technological growth of cities. This perspective was further altered/augmented by the appearance of the terms 'Digital city' and 'Cyber city' between 1990 and 1995 wherein three-dimensional computer-generated visions of cities and digital metaphors of the city as well as the electronic management of city governance and security and control systems was advocated by authors such as Malina (Malina, 1993); Poggenpohl (Poggenpohl et al., 1995), and Graham (Graham, 2004). The 'Smart and Intelligent' city discourse thus immersed itself into attributes of ICT and innovation while the 'Cyber and Digital' city ventured into virtual representations and electronic governance and surveillance of the city. This era was followed by an explosion in research and experimentations within the domain of smart cities, primarily between 2000 and 2010. This was invariably linked with the advancements in ICT wherein telecommunication networks, sensing systems, knowledge management tools and embedded intelligence (with the rise of ubiquitous computing) during this era were prominent. Developments in software for data management and the miniaturization of technology further made it possible for our cities to be populated with technologies for gathering, communicating, collecting, and analyzing data produced by the city and its embedded services at a much faster pace, which slowly resulted in contradicting and questioning the role of virtual representations and generative logics that were predominant during the Cyber and Digital modes of thinking about the city.

A plethora of authors ranging from Hall et al. (Hall et al., 2000), Komninos (2002), Odendaal (2003), Patridge (2004), Gliffenger et al. (2010), Harrison et al. (2010), Chen et al. (2009), Craglieu et al. (2011), Hernandez-Munoz et al. (Hernández-Muñoz et al., 2011), Batty (Michael Batty et al., 2012), (Bakici et al., 2013) Komninos (Komninos, 2015), Nam and Prado (Nam & Pardo, 2011), (Barrionuevo et al., 2012), Zygiaris (Zygiaris, 2013), and (Marsal-Llacuna et al., 2015) to name a few have presented their definitions of smart cities, which vary significantly from each other, thus deepening the confusion around labelling the city as 'Smart'. Despite ICT remaining the most common element in all these definitions, it becomes evident that post the year 2000, a shift in the mode of thinking from a technocentric vision of smart cities included focusing on 'People' as well as 'Community needs' in a much more integral fashion. This shift in focus also implied a much more holistic focus on improving quality of life by means of using ICT in a manner which improves the way in which every sub-system operates (Batty, 2012). This, in-turn implies that ICT, which is predominantly connected with the term 'intelligent' and in today's context with terms such as 'Artificial Intelligence' needs to adhere to the fundamental quality of being adaptive and responsive to user needs.

Large technological corporations such as IBM, Cisco, Siemens, etc. naturally value technical components as the key to conceiving smart cities. Services ranging from waste, water, energy, security, transport, lighting, buildings, etc. are increasingly deploying such technical modes of harnessing data albeit in a siloed fashion. This results in the aggregation of sectorial big-datasets, which does not primarily aid in understanding the city as an ecology of interconnected services. Adam Greenfield, in Against the Smart City (Greenfield, 2013), is one of the many authors who reinforces this opposition for a technocentric vision of Smart Cities and sites various examples of so-called smart cities which have failed to perform because of little to no attention to values vested in mixed use, people centric design, and urban complexity. This technologically propelled perspective of denoting and ranking our cities as 'smart' might not necessarily be the only perspective. On the contrary, this if seen from an ethical perspective could result in issues of social exclusion, inequality,

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injustice, and non-resilient modes of urban development rather than promoting a people-centric all-inclusive vision for developing a 'smart and just' city (Vangelis et al., 2017), especially seen from the context of developing nations and their desire to increasingly adhere to the 'Smart City' badge.

In order to extract the essence of these definitions and scope of smart city related discourses, the next section presents a consolidated view on two aspects: Categorization of smart cities and the Trends observed in operating smart cities.

3. Smart City Categories

Based on the confusions, discussions, and debates around the term 'Smart City' presented in the earlier section, the following three categorizations of smart cities can be made:

3.1 The Technology Driven City

This vision is primarily associated with a Technology Centric agenda wherein large-scale multinational ICT providers such as IBM, Siemens, Cisco, etc. encourage and promote the adoption of their proprietary ICT solution to governmental bodies. With its allure of innovation and business opportunities which is highly appealing to urban technology innovators, star-ups and investment firms and the ability to create jobs and impact the economy in a positive fashion, this category of the city can be primarily seen as a city embracing a corporate commercial model. IBM, the primary promotor of this ideology, through its 'Smarter Planet – Smarter Cities' initiative (Palmisano, 2008) has been progressively attracting multiple commissions with various cities globally in order to set up their 'smart' vision. America, in particular, has adhered to this 'corporate smart city model' wherein technology has been advocated as a cure/solution to any and all social, economic, service, and cultural problems. Many criticisms and examples such as PlanIT in Portugal, Songdo in Korea, Masdar in UAE, etc., which are often termed as 'empty cities' are sighted as a bi-product of such models. Researchers such as Anthony Townsend (Townsend, 2013), Soderstrom et al. (2014), Aurigi (Aurigi, 2006), Graham (Graham, 2000) etc. have argued against this model of development.

3.2 The Government Driven – Technology Led City

This category of Smart City is the one wherein the city administration increasingly focuses on deploying technology solutions as enablers to improve the quality of life of people. Authors such as Damieri, (Dameri, 2013), Cocchia (Cocchia, 2014), Kitchin (Kitchin, 2014), to name a few have written and critiqued this approach from the perspective of 'Top-Down' urban planning perspective. This implies that administrators and political class, including municipalities, without the actual or rather limited involvement of the people, deploy their vision of a smart city. This deployment is usually carried forth in consortium with Technology providers and tends to carry an inherent ideology of the all-knowing administrative class whose thinking will genuinely benefit people on-ground. Prominent examples of such cities include the Songdo Business District in Korea, the Incheon Eco-City, South Korea and the Busan Green u-City, South Korea. IBM and its involvement with the Mayor of Rio for deploying IBM's proprietary smart city solutions within the city to monitor landslides, crime detection, central operation centers, etc. is often seen as a prime example of this category of Smart City. However, criticism against this category of smart city is purely based on the decreased potential of understanding, involving, and co-creating the city with people on-ground who are ultimately to benefit from the mega-investments, which smart cities involve. Citizencentric and democratically empowering processes, which would otherwise benefit in the creation of responsible and ethical cities rather than satisfying the demands of major ICT corporates is thus a negative aspect attributed to this category.

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3.3 Citizen Co-Creation Driven City

Citizen co-creation, as the name suggests, is a trend that has now caught the attention of various Governmental bodies. After having understood the pitfalls of the previous categories, this category involves processes wherein governments and citizens collectively operate to co-create solutions and raise concerns, which ultimately lead to transparent governance-based development of the city. One can also term this as a shift towards embracing collective intelligence in conjunction with data-driven intelligence. This implies blending the intelligence of citizens/public, intelligence from city's institutions, infrastructure, buildings, and intelligence gathered via data platforms of crowdsourcing, mobile phones, IoT devices, wireless sensor networks, etc. This enables static as well as dynamic real-time data to be incorporated into decision-making processes while more importantly provides the citizens with a platform to actively engage and be heard within processes of evolving their city. Cities such as Vienna, Vancouver, Medellin, and Barcelona have set examples of ingenious urban regeneration strategies, which engage citizens from even the most vulnerable neighborhoods to produce socially responsive urban inserts and innovation districts. According to Robert Ng Henao, an economist heading the smart city department at the University of Medellin, "Medellín's vision of itself as a smart city broke from the usual paradigms of hyper-modernization and automation". He continues to say that "It replaced them with a more anthropocentric vision of the city's future" (David, 2019). This movement has also seen the rise of the 'Sharing City' culture where bottom-up citizen platforms for sharing resources and services are on the rise. A human centric perspective towards developing the city into a holistic smart and equitable place can thus be seen as an emerging ideology.

After this concise description of the categorizations of Smart Cities, the paper will now provide snapshot of two prominent trends of operation within smart cities.

4. Smart City Trends

Smart city governance and operation trends can be roughly categorized into the following two predominant trends:

4.1 The Urban Operating System Approach: A top-down Perspective

The primary characteristics of this mode of operation can be traced as:

a) The Local Government leads with centralized data collection, information generation and decision making.

b) Information is primarily collected through sensors and IoT systems embedded throughout the city and is assimilated in the so called 'Central brain' or smart city data centers, which are primarily owned and controlled by the government (though the ICT applications are predominantly proprietary of multinational ICT corporates).

c) Cross-sectional or Siloed data is usually put together in these data centers in order to mine for new patterns of social, economic, demographic, infrastructure etc. trends. This in-turn results in the development of new policies and orchestration of daily operations.

The Technology-Driven City as well as the Government-driven Technology-led categories of cities such as Rio de Janeiro, Bandung, Bhopal, and Glasgow to name a few have invested heavily in setting up such integrated control command centers in order to harness big-data and real-time information for improved service offering to the city. Reaction to unusual patterns observed within the collected data, in the form of prediction of environmental calamities, congestion, infrastructural overloads, crime, etc. becomes the primary aim of such control command centers. Typical architecture of such centers

involves the systematic working of the following layers: Application and devices layer (including audio, video, environmental, energy and crowdsourcing hardware), Integration layer (involving application programming interfaces, software development kits, webservices and databases), Analytics layer (including command center platforms, data analytics suites, AI, video and audio analytics packages and predictive learning), and the Integrated Control Centre (including interactive digital wall, operators computer terminals, situation rooms as well as local server rooms). However, points of critique for this trend can be elaborated as follows:

a) Concern over the responsible use of centralized information is considered as a big concern. Sensitive information which can cripple cities as well create social unrest and impact economies thus needs to be scrutinized and managed by responsible people in power.

b) Protection against security breaches is of primary importance in order to protect and safeguard the city's performance engines. Cyber security as well as physical breaches into the servers etc. are of prime importance.

c) Human rights violation and social inequity are a bi-product of this non-transparent form of decision making wherein data collection, analysis and policy making all happen independent of citizen involvement. Situations of imbalanced economic investment and urban growth to benefit certain sectors of vested interests could thus become a dangerous proposition.

4.2 The Self-Organizing System Approach: A bottom-up Perspective

This approach, as the name suggests portrays a bottom-up initiative to understand the city. Some benefits of this approach can be outlined as follows:

a) This approach follows a decentralized model that relies on citizens to generate, share, and make the most of the data to inform decision-making processes.

b) This approach truly harnesses the power of crowd-sourcing and human-in the loop models wherein the role of the citizen and the demands and needs of the citizen gain primary importance.

c) Local authorities are usually responsible for building common platforms guaranteeing the availability of proof of data to citizens, regulating usage and responding to needs of the citizens.

Lately, multiple applications such as Nextdoor (https://au.nextdoor.com/), Neighbourlytics (https://www.neighbourlytics.com/), etc. which are more focused on the scale of precincts rather than the entire city, are good examples of this approach. Such applications, via the use of citizen participation not only help in understanding neighborhoods from a grass roots level but also are ultimately able to measure quality of life and wellbeing in cities. Data aggregated from local sources such as restaurants, public social media sites, comments by locals, etc. are usually compiled into interactive dashboards in order to be accessed openly in rather intuitive formats. The regular citizen as well as government bodies, town planners, urban developers, etc. are accordingly able to develop and deliver propositions that are based on this ground level understanding of the community and hence are able to benefit local conditions by producing socially and economically viable conditions. Sharing platforms such as Repair Cafes (https://repaircafe.org/en/), as well as platforms such as Gumtree, Marktplaats (The Netherlands), etc. are all new business models wherein people share, exchange, and sell services as well as goods instead of throwing unwanted goods into landfills. Such bottom-up collective effort of citizens presents a new opportunity for re-thinking and evolving the city in a bottom-up perspective.

Issues such as non-scalability of certain platforms as well as non-equitable development of the city primarily based on the demographic, financial and digital literacy rate of the neighborhoods have been seen as limitations to this approach.

From this cursory account of a Smart City, its chronological evolution, categorization and operational structure, outline fragmentation as regards consolidated views on a singular definition as well as operational models. These have also resulted in diverging research directions, which highlight the points of debate between the technical, the social, the collective, the top down, and the bottom up counterparts of thinking about the smart city. It has also become substantially clear that Technology and its growth has had a significant influence on shaping cities and influencing both governmental bodies as well as the citizen wherein the smart city debate again diverts between corporate models of smart cities vs user based participatory means of governance. In order to speculate on a neutral and balanced model, this paper further suggests understanding and conceiving smart cities as socio-technical systems in their own right. A concise discussion on this view including a model for understanding the city as an ecology is thus presented in the following section.

5. A Socio-Technical System (STS) Model for Developing Smart Cities

Socio-technical systems in essence try to embody interactions between people, technology, and environments (Stevens & Salmon, 2017). It is interesting to note that such a system considers hardware, software, personnel as well as community aspects and thus offer a perfect solution to the otherwise technical or human focused attitudes towards developing smart cities. Fusion between social science domains such as social structures, rights, roles, behavior, etc. and technologies and community structures are thus at the crux of such systems. With a basis in 'General Systems Theory', which focus on the common element 'Systems' within all sciences thus creating a situation wherein no one particular science outweighs the other, a democratic platform for integrating multiple facets of a city can be offered via this perspective. Interestingly, a new perspective on technology, "technology being built to social requirements" wherein there is an inherent understanding that participatory rather than top-down technocentric approaches lead to a fulfilling future, can thus be put into practice. A community level-based understanding from a holistic perspective, which the STS model promotes, is thus considered far higher in value than purely Mechanical, Informational or for that matter purely Human level (Whutworth & Adnan, 2013) and can thus benefit in envisioning the smart city.

User participation (all stakeholders), within the process of conceiving smart cities is thus of paramount importance in order to avoid a siloed focus on the development of a city. This can allow for a variety of benefits such as: Greater engagement between stakeholders and associated technologies; democratic ways of gathering, sharing and understanding data (on-ground, which outlines multiple needs, behaviors and traits); understanding of how the city operates in its original form; and extrapolating information from gathered data in a transparent manner and thus developing an informed understanding of what and how to improve the city/system. This crucial human component can prove very critical in developing successful renditions of so called 'Smart' cities, which essentially develop owing to a fusion of collective and responsible data driven perspective. After the Travistock Institute of Human Relations coined the term 'sociotechnical' (Mumford, 2000), authors and thinkers such as Albert Cherns (Cherns, 1976, 1987), Enid Mumford (Effective Technical & Human Implementation of Computer-based Systems (ETHICS) (Mumford & Weir, 1979)) and many others have written extensively on the socio-technical perspective.

Leavitt's (1965) Diamond (Fig. 1), also called Leavitt's System model, is a model for understanding the effects of a change strategy on an organization. This research conceptualizes Leavitt's model to a customized socio-technical system model (PACT model) for conceptualizing smart cities. Leavitt's model consisted of four key components, which are all interdependent and exchange information with each other: Structure, Technology, People (actors), and Task. Herein, (a) People are not only looked at from the perspective of their designations but also from the perspective of their skills, efficiency, knowledge, and productivity; (b) Tasks include goals and thus involve a deliberate link between how things are being done currently and what one is trying to achieve; (c) Structure apart

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from understanding hierarchies, is also concerned with understanding relationships, communication patterns, and coordination between different subsystems such as management, departments, employees, etc.; and (d) Technology is seen from a faciliatory perspective for enabling people to perform tasks. Understanding the impacts of each of these elements on each other in order to assess the impact of a change and thus taking informed decisions is what is of primary importance within this model.
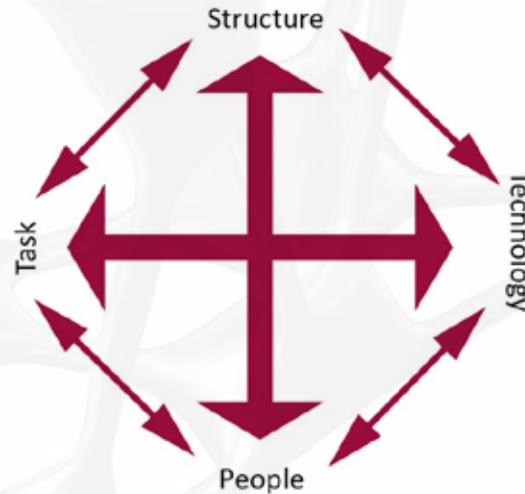
Figure 1: Leavitt's Diamond/Leavitt's System Model (Image source: ACCIPIO, https://www.accipio.com/eleadership/mod/wiki/view.php?id=1837)

The city on the other hand, is a complex socio-technical system, and in the case of this research is considered as an 'Ecology' of four interlinked components in its own right. An adapted model for the informed bottom-up conception of smart cities as shown in Fig. 2 thus introduces these four components as: People, Activity, Context and Technology. Borrowing from the PACT framework proposition, popularized by David Benyon via his book Designing Interactive Systems (Benyon, 2014), the City is seen from the perspective of real-time interactions between these four components, which ultimately shape the idea of an 'Ecology'. Ecology, by definition is a branch in biology, which studies the interactions among organisms and their biophysical environment (both biotic and abiotic components).
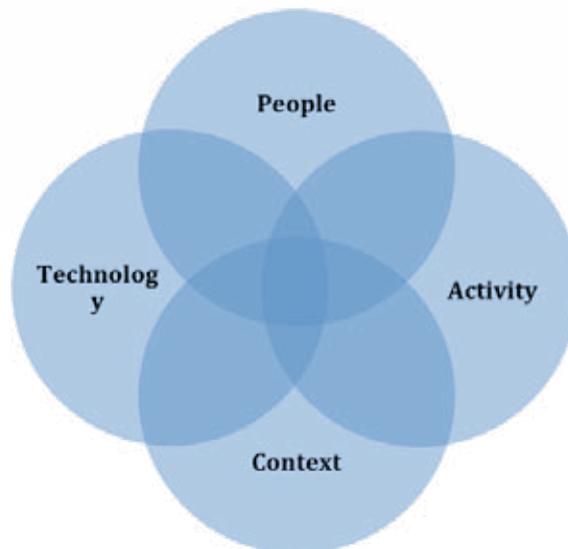
Figure 2: Proposed PACT Model with the city considered as an ecology (Image source: Author)

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The proposed model in the case of this research paper is based on the premise that people perform actions as a response to their immediate context with the aid of technologies. A looped logic in the form of activity-based requirements of people which give rise to user-centric technologies, which, in-turn can create opportunities that can change the nature of activities being performed in different situations is thus at play. Acknowledging the fact that people are dynamic actors, who, change their requirements and look for improvements and innovations to impact their wellbeing, and thus acknowledging the city as a dynamic ecology which is in a constant state of flux should lie at the core of developing a smart networked practice for impacting the city. Therefore, solutions sought at the intersection of these four components while keeping in mind the dynamic cyclic nature of evolution and thus the inherent scalability of the solutions (Smart ecologies: SE, as seen in Figure 2) as an ecosystem should constitute the smart city. This ecosystem of implemented solutions is what should ultimately define how smart a city is.

In this proposed model, the following is the manner that we can break down each component:

6. People

Firstly, it is important to understand that people are diverse in their inherent nature, thinking, liking, and behaviors. Attributes belonging to both physiological and psychological aspects of our operations thus need vital consideration. This is also particularly important that the smart solutions being developed are equitable and ethical and are responsive towards the differently abled and the vulnerable sections of the society. From a wider stakeholder perspective, People, as a terminology covers users/everyday citizen, city administrators and associated government bodies, as well as corporations who have their stake in the development of the city. The requirements of each of these groups with respect to the services that are being developed should be considered. This implies thinking about the everyday user of the developed service (for instance finding a parking spot quickly and easily); about the systems operator (in charge of maintaining local smart solution systems such as parking apps or smart bins); about the systems developer (in charge of conducting predictive analysis on the collected data); and about the managers (managing overall consumption vs production logics of the respective service). It is thus of vital importance that the nature of activities and the context within which these activities are being performed by these diverse set of stakeholders be considered before imposing technologies. On the contrary, technological development should be imbedded within this understanding of relations, needs, and behaviors of the stakeholders. Factors such as user acceptance owing to the perceived ease of use, the benefits and usefulness as well as the careful crafting and introduction of technologies within a given context to promote behavioral change are all critical to the success of any smart city. Administrators as well as corporations should also be equally participative in order to develop more transparent modes of governance as well as communicating outcomes, benefits and failures apart from taking leadership in adopting participatory models (such as the quadruple helix model wherein governments, industry, academia and citizen groups collaborate) for the development of smart cities.

7. Activity

This component concerns understanding the variety of activities and tasks that people perform and thus extract the nature of services that need to be provided and improved upon either with or without the aid of technology. This implies understanding both the purpose of the activity/task as well as the critical features that aid or disrupt the performance of the activity in an optimal fashion. Essentially cities and their operations which impact the wellbeing of the citizens can be categorized via the following service provisions: Transport (accessibility, infrastructure development, etc.), Health (both mental and physical), Environment (including pollution, heat, climate impact, energy usage), Education (educational institutions and associated policies), Real-estate and public spaces

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(management and maintenance), Safety (law and order, emergency services, etc.), Economy (business growth, job creation, incentives, etc.), Utilities (water, gas, electricity, waste removal, etc.), and Administration (monitoring, city planning, legislation, etc.). It is critical that before heavily investing in technologies to enhance these essential activities and tasks we analyze, understand, and reason the necessity and the expected impact which is expected by the so-called smartification of these activity segments. Besides this, it is also vital to note that the city can also be seen as a collage, which implies that different suburbs have different needs, demographics, and contexts, which render the careful attribution of development of the aforementioned segments in different proportions. One strategy fitting and solving the needs and requirements of the entire city is thus not necessarily the correct way to approach the city. The role of people/communities and their socio-cultural as well as economic contexts thus becomes key to deploying smart measures. For instance, strategies such as reduction of traffic congestion vs encouraging use of public transport and active mobility means; energy supply vs reduction of waste; increasing better level of education vs maintaining affordability of good education; increasing e-health opportunities vs understanding digital literacy; increasing police presence vs encouraging social policing; deploying smart bins vs understanding the demographic and real-estate based migration patterns, etc. should all be determined after carefully understanding interrelated impacts of the proposed STS components.

8. Context

As is clear from the above expansion on the term Activity, it is important that 'Context' and 'Activity' be interlinked intrinsically while understanding the city. Context in this sense varies from social, economic, as well as geographic phenomenon, which, in themselves are determinants of the nature of activity being performed. These in-turn impact the manner in which nature of communication with governmental bodies and city administrators (deployed using smart technologies) would need to differ in order to receive feedback from the people on-ground. Socially and economically backward locations are often synonymous with high rates of crime, non-unitary community front, hierarchical managements, and often suffer from lack of education and digital literacy. In such circumstance's traditional structures of governance, wherein people (in biased and at times forced or coerced situations) elect governing representatives and thereafter are not engaged in decision-making processes, take precedence. The slow yet participatory modes of engaging with such contexts in order to educate as well as learn about intricacies of social, economic, and powerplay modalities is thus vital instead of imposing an all-knowing smart surveillance system. This is particularly useful if one needs to look at long-term solutions and gradually build up context sensitive smart means of evolving the status of such sensitive contexts. Strategies for engaging citizens by providing them with a transparent and democratic platform for participating in decision-making processes is thus key to developing smart and ethical cities. Besides this, geographic contexts, which present their own challenges in terms of terrain, flooding, over-densification, urban heat gain, excessive consumption of energy as well as hindrance to positioning of economic generators owing to susceptibility of city regions are also vital and should be considered while deriving smart and resilient place making solutions. Precinct level solution sets, which are deeply embedded in understanding local contexts are thus considered key to developing networked smart ecologies.

9. Technology

As is evident from the discussions pertaining to the above three interdependent components, Technology should be highly interconnected with supporting and aiding people in improving and enhancing their activities within their respective contexts. Rather than a top-down construct, Technology, specially within the domain of smart cities, should evolve in a bottom-up user and context centric manner for it to be accepted without disrupting ethical boundaries. Technology within the city can take up multiple

forms. If we look at it at a scalar level, then we can essentially categorize it into two levels:

- The city's civic infrastructure scale

This can range from most essential 'network infrastructure' provision in the form of internet connectivity (both fixed and mobile broadband) as a fundamental human right for enabling unbiased communication options; 'IoT and distributed sensing systems' to monitor, capture and relay data pertaining to environmental factors (urban heat, water levels, pollution levels, air quality etc.); civil safety and security (street cameras, integrated panic buttons within smart light poles, adequate lighting etc.); traffic and mobility infrastructure (smart parking, optimized paid parking etc.); services monitoring (energy, water, electricity production vs consumption, smart bins and regulated garbage disposal etc.).

- The context specific governance scale

These are in the form of control centers for data assimilation, storage, and analysis to enable transparent and un-biased decision-making. It is vital though that such data centers also incorporate citizen needs and contextual condition-based datasets as a part and parcel of the decision-making process rather than simply taking a siloed view on the gathered data. A leap from big-data thinking to linked-data thinking is thus of prior value for any smart city initiative. Clever ways of embedding and extracting knowledge from qualitative feedback of users together with the more granular quantitative data sets collected from the city's civic infrastructure scale is thus key for developing associated software and AI and Machine Learning protocols within such control havens. Apart from technologists, the proposed PACT framework encourages decision-making to become a collaborative process wherein citizen, specialists from multiple domains, economists, sociologists, technologists, etc. are given equal opportunity to understand datasets and are thus able to present informed suggestions for the better governance of the city.

- The user/citizen scale

These are quintessential interfaces enabling communication (bi-direction communication should be given preference). Apart from citizen reporting platforms, which make governing bodies aware of the on-ground difficulties that citizens face every day, collaborative platforms in the form of mobile applications such as the Neighbourly app, dedicated citizens forums, community web sites, newsletters, IoT enabled precinct scale reporting tools as well as health and fitness-based applications, etc. are all a part and parcel of such citizen scale initiatives. Community engagement on sensitive issues such as safety for women, children and elderly as well as the state of existing infrastructure which services their own needs daily by the intuitive use of technology is thus crucial to understanding the state of the city. It is this aggregated on-ground reporting wherein people themselves transform into sensors and thus part-take in developing data streams which influence active decision-making, which is much needed for developing healthy and ethical smart cities.

10. Conclusion

This research, while shedding light on the term 'Smart City', elaborates upon the categories and operating trends of smart cities and outlined two prominent yet conflicting ideologies: Techno-centric vs Human-centric, which persist till date. Socio-Technical Systems oriented approach towards understanding the city has been proposed as an ideal approach towards diluting and merging the pros and cons, which emerge from this ideological debate. Herein, a case for an ecological perspective for understanding and re-thinking the smart city in the form of a People, Activity, Context, and Technology

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(PACT) model is presented. It is also imperative to understand the city as a dynamic eco-system in its own right and thus the sustained need for understanding the needs, demands, and desires of citizens with respect to the social, economic, geographic, and cultural context within which they perform activities with the help of technologies is presented as paramount. These four components and their equal status (akin to general systems theory perspective) has been projected as a given in order to build resilient smart cities. One can thus project perceiving the 'City as a Laboratory' as an appropriate way to progress towards attaining the goal of developing smart cities via iterative experimentations using the proposed socio-technical system model. Local urban dynamics in conjunction with local needs and the appropriate infusion of technologies while understanding the context within which cities need to evolve is thus the key to developing smart design ecologies which will in turn produce smart and sustainable cities.

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Non-Cooperative and Repetitive Games for Urban Conflicts in Tirana: A Playful Collaborative System to Lower Social Tension

Sotir Dhamo, Valerio Perna, Ledian Bregasi

Universiteti POLIS

Tiranë, Rr. Bylis 12, Autostrada Tiranë-Durrës, Km 5

valerio_perna@universitetipolis.edu.al

Abstract

Game Theory (GT) offers a critical lens to understand and analyze the capacity of different actors to make rational decisions linked to complex and emergent situations. Even though developed as a theory to tackle economic issues, GT has found a wider range of applications in heterogeneous fields such as architecture, where this new transdisciplinary tool can be used to address topics such as urban planning and public participation. The objectives of these researches aim for avoiding ghettoization, lowering social tension, and conflicts, and for proposing long-term solutions in a reality where the lack of authority has led to the development of closed informal clusters at the outskirts of the city.

In this paper, we present the city of Tirana as a case study to develop our speculative research in an operative field that blends GT, computational design, and morphological/behavioral patterns. Non-cooperative and repetitive games are useful tools to identify generative patterns in the Albanian informal settlements, with the certainty that even the most spontaneous ones carry within them positive enzymes that can be taken into account to re-organize the informal settlements either spatially, socially, and economically (Dhamo, 2017, 2021). We propose a set of operative categories, filtered through the lens of GT and playful dynamics and mechanics, to set the debate for a deeper understanding of the reality of informal areas and foster co-design processes, from the perspective that collective interest is a key to let professionals, institutions and citizens work together in a more informed process of city-making.

Keywords: Games and simulation; Informal settlements; Bottom-up strategies; Playful interactions; New city-making processes

Tirana: Management Issues in Conflictual Urban Spaces

Each city is a unique phenomenon. The specific characteristics they develop throughout history are often considered as "atypical" and tend to be sterilized because they do not meet our preconditions/taboos of how the world should be. These characteristics constitute the most crucial enzymes for cites. Our interest is the city as the nucleus in which all the forces that make it, express themselves, converge or diverge; where political power is expressed concerning urban space, and where the conflicts take place. But, can we identify design methodologies and operative categories that help to face through an alternate way conflict management in urban spaces?

Tirana is an excellent case to study these phenomena, being a place where people and authorities have been continuously on two opposing fronts related to city making/building issues. Substantial parts of Tirana are spontaneously developed and not yet fully recognized by authorities. This fact generates endless conflicts and a series of precarious equilibriums. There is evidence about this conflictual relationship: starting from the last conflict in the city-ring area where the so called informal people fighting for their recognition are blocked parts of the city or the protests that developed during the mid-90s for the same reason; not to speak about coercion on people during the communist regime for

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living in their houses, to name a few.

This being said, governments were never able to guide urban development and create the standard conditions for growth, contrarily, it seems they always fought the natural tendency of people to urbanize. In fact, in Tirana, people better than architects understood the sense of place and organically became protagonists. It is the creative role of people that makes Tirana what it is: a city personalized/ privatized in every corner.

In our opinion, this is the reason why the deterministic and one size fits all regulations applied in Albania were discredited and rejected by people; more than any "informal" process they contributed to sterilize the idea of the city/place. This is the reason why we need to discover "the secret" enzymes that inseminate the organic processes in Tirana and try to bring them back in the design process through a conscious way.

The descriptions related to the generation of the patterning process and their specific emergent qualities that follow, has been built on previous research activity "Specific realities and new hypotheses for urban analyses and urban design-Tirana as a case study", developed in the framework of the PhD program in architecture and urban planning between POLIS and Ferrara universities. In this research, the transformation of Tirana's urban morphology is seen from a theoretical perspective to outline a new hypothesis for city design.

Rules of the Game: Principles and Patterns for the Albanian capital

1. Analytical principles

To overpass the handicap described above and understand a more holistic dimension, we need to see the reality of Tirana under a different theoretical lens. Differently from the mechanical view, according to which the reality equals the sum of its parts; quantum reality is a container of infinite potentialities, tendencies, and interactions, where "things" enter in correlations in a larger whole (Zohar and Marshal, 1994). Therefore, trying to understanding the invisible structure of associations, and their interaction as part of a larger/continuous whole is crucial. Concepts hired from quantum, fractal, and complexity theories helped to overcome mechanistic = deterministic approaches. Concepts hired from quantum theory, based on the particle-wave duality, see this relationship as a malleable energy field (Arida, 2002) created by the overlapping wave effect.

This kind of unbroken web (Zohar and Marshal, 1994) creates the society-space-time (SST) continuum (Arida, 2002); fractal city theory (Batty and Longley, 1994), sees relationships as recursive behavior (regular/irregular) of elements, that create the internal/invisible form, grouped in a hierarchic structure; and complex systems theories see the relationship as a macroscopic behavior or self-organization of a collective whole which arouses through the interaction of large numbers of entities following underlying simple rules, but without a central controller that tend to self-regulate through signaling, and information exchange (Mitchel, 2009).

The emergent qualities of specific patterns in Tirana are not a mechanic sum of its parts but involve a relationship. The quantum correlation effect across space-time happens organically in the city separated "things" are aspects of some larger whole (Zohar and Marshal, 1994). The arousal effect of the wave factor from local/non-local-temporalities affects the local-temporal environment and gives rise to new emergent qualities. This is the reason why we start with historical analyses and conclude with a critical reflection on how specific patterns can be catalyzed/embodied in parametric systems that allow us to analyze and interpret quantitatively and qualitatively.

2. Historical Brief and Patterns in Tirana

We present first a brief description of the historical conditions that produced the SST continuum (Arida, 2002). The evolution of the first organic nuclei of Tirana started at the beginning of the 17th century (Frashëri, 2004) in the intertwining of important regional commerce routes when this territory was under the domination of the Ottoman Empire. Their evolution was nourished by a combination of local preconditions, such as physical determinants and land divisions (Kostov, 2003), social factors (patriarchal enlarged family, etc.), with a premeditated strategy of the Imaret system (called later kulliye) (Ingersoll and Kostov, 2013) used by the Ottoman Empire during the 14th century as charitable institutions and city foundation devise.

As these authors argue, gradually Imarets became centers of well-defined neighborhoods grouping around the mosque other buildings, including economic activities. Generations and traces inherited under this condition have been analyzed under PATTERN 1: Historic Organic. This pattern is a direct descendant of the imaret/kulliye system of the city foundation, but it is a new emergent reality created by overlapping of the associated wave factor generated from a non-local-temporal environment (but within the SST continuum) with the local-temporal conditions. This pattern is a process during which clusters of houses based on group affiliation/family ties, driven by an introvert behavior motivated by the (Islamic) principle of the right on visual privacy, generate a recursive process legible in the modality of refracting the straight-line and isolating between interstitial buffers. This process results in a self-similar/self-affine visceral quality of space through scales. The pragmatic in-fill that happened during the last two decades in these areas is a simulacrum of the historic organic: it is similar in shape but incoherent in its meaning.

The phase from 1920-1944 represents the first efforts to move from organic to a designed city or from the Ottoman system of Imarets to the Europeanization of Tirana. These attempts were represented first in King Zog's interventions for the ceremonial complex of the ministry square, and the central axis of the boulevard; and almost a decade later during the Italian fascist occupation for the construction of "Piazza Littorio". These interventions that carried a completely different philosophy and mentality from the Ottoman Tirana introduced a new dimension in public life and a new dialectic between organic and geometrically designed parts of the city.

The phase from 1945-1991 under the communist dictatorship represents a social experiment that attempted to create a new physical and social reality. Architecture and city design followed ideological principles supposed to support the so-called revolutionizing of the entire life. They needed to create an egalitarian environment and "kill" any differences created during history: a city designed by demolition and building a new one in morphological opposition with the historical traces became the norm. What mostly transformed Tirana during this period were the 4-5 stories of poor/low-cost standardized a-stylistic housing blocks: a city between empty frames deprived of the human spirit and historical specificities: a city people wanted to abandon.

This condition of emptiness served as the main base for PATTERN 2: Recording Over. This pattern is a re-engraving process that transforms not only the pre-designed frames defining the space but also the space itself. This is a gradual process where a mass of so-called agents, driven by an inward behavior, coordinated in small but motivated by an act of re-appropriative revenge against the public space (because of the denied property rights during the communist regime) generated a recursive process legible in the modality of wrapping the space and the buildings/frames from within or from without. Such process results in a self-similar/self-affine involute quality of space through scales.

The phase that started from the beginning of the '90s with the collapse of the communist regime was characterized by rapid uncontrolled urbanization and the emergence of informal suburbs in the periphery. In parallel, the public space in the center was reduced through progressive infill. It was a

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kind of return to the organic city. Tirana lost the compact form and entered into a phase of dissolution. In the vision of the Berlage Institute (2004), Tirana was a metropolis still under formation. Despite efforts to stabilize limits of urbanization, Tirana continues to grow in a shapeless organism with endless ramifications swallowing preexisting settlements, resulting in a more significant and unstable organism. However, from 2010 until this date, the trend in the construction industry and urbanization calmed down. This recessive trend is still in progress.

Generations and traces formed under this condition have been analyzed under PATTERN 3: New Organic. This pattern is a process during which individual houses grouped in the urban/rural space acquire a certain masse through densification or dispersion. This condition of isolating (to hide from authorities) results in a self-similar/self-affine collapse in the quality of space itself (no anthropological principles) through the modality of compression, or in the inflated quality of space through the modality of floating the nucleus or sparse houses in the rural space. There are some similar formal characteristics to the Historic Organic pattern. There are differences in the reasons that motivated this pattern and in the anthropological factors that triggered the motive.

As pointed out, the city of Tirana is in need to solve its management issues in a more conflictual urban fabric growth. In the next paragraph, we will explore the possibility of a game-based strategy to propose a divergent lens to address these issues. Games are a speculative tool that can be helpful to trigger new reflection and to give architects and designers-new methodologies at hand. Our approach for this work is 'non-solutionist', we believe that the informal development of the city since always being a part of its generative DNA, is not an issue to solve in any way, but a widespread point to be taken into account by the design community, which deserves a much better understanding and needs a new approach towards problem-solving.

Games and Architecture: Playful Systems to Confront anti-Participative Systems

The use of games in architecture and urban planning is not new. Their implementation has a long history since the 1960s (Abt, 1969; Duke, 1975), and has remained a favorite tool for spatial modeling and simulation, and public participation (Mayer, 2009; Poplin, 2012). In the last decade, we have seen the rise of urban play as a tool for community building and city making (Tan and Portugali, 2012; Tan, 2017), and western society is actively focusing on play/playfulness as a way to approach complex challenges and emergent situations. Even though games and play have entered the mainstream in a wide range of different contexts, and the combined study of games and cities (Nijholt, 2017) is gaining more and more attention from academic researchers, we still lack a specific definition of what a game is.

We agree that a game is a "form of structured play" (Salen and Zimmerman, 2004) and that four conditions are required to call an event a game (Suits, 1978): 1. A clear goal, 2. The need for performing explicit acts (rules) to reach this goal, 3. A collective agreement among players to embrace the rules and work towards the goal, 4. Players need an assessment loop for continuous motivation. If a recent statement invites people to "play anything" (Bogost, 2016), we see no side effects in attempting to bring game dynamics and mechanics in a complicated and risky field like the architectural one. Since participation and civic engagement have increasingly formed a significant part of urban planning and governance (Gordon and Mihailidis, 2016), we identify the need of using games as new tools to trigger participation and to address a variety of aspects in urban planning such as design issues, stakeholders negotiation, deliberation, and self-organization practices (Glick, 2012; Grahan & Marvin, 2001; Krasny, 2013). The current situation of the city of Tirana represents for us a privileged field of study, because after the fall of the dictatorship, the evolution of the urban fabric has always been based on anti-participative systems where the social tension has always been exploited for personal claims rather than been solved.

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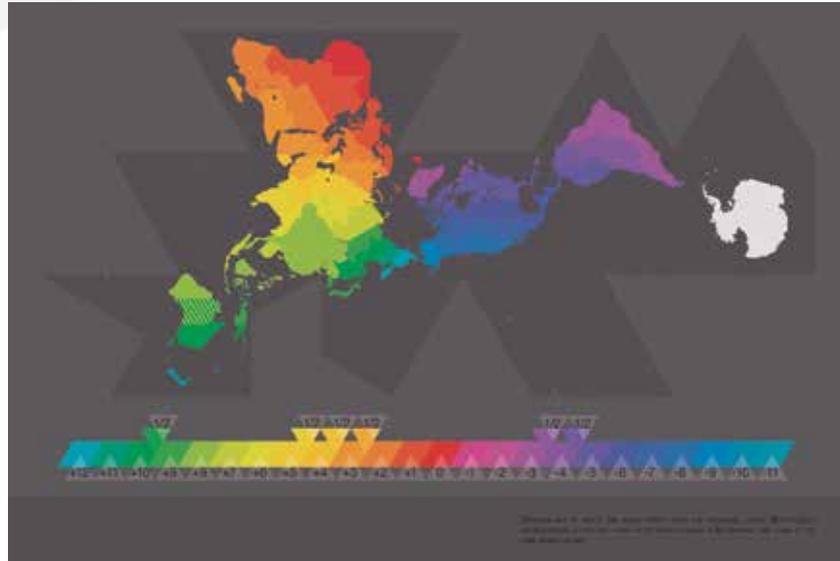
Figure 1: Buckminster Fuller, World Game, 1961-Reconstruction of the game board for the game's anniversary. The game is described by the Buckminster Fuller institute as a "great logistics game" and "world peace game" (later shortened to simply, the "World Game") that was intended to be a tool that would facilitate a comprehensive, anticipatory, design science approach to the problems of the world.

Notions of Game Theory: Solution Games between Balance and Conflict

> "*A game can be described in terms of strategies that players have to follow within their moves: we have a balance when no one can improve its behavior unilaterally. To change, it is needed to act together*"[1].

To understand the deep relation between architecture and games, and how the latter can be used to tackle complex urban challenges, it is necessary to deal with some notions of Game Theory (GT). This excerpt is systemic to our research for two reasons: on the one hand, to show how playful systems can be implemented in multiple areas with useful-and not only hypothetical results; on the other hand, to create the bond within games, city, and urban planning, that will set the base for our operative experimentation. Game Theory was in gestation for most of the early nineteenth century, but then it developed between the Sixties and Seventies and found a more substantial diffusion in the last quarter of the previous century (Bilancini, Boncinelli in Bertolo, Mariani, 2014). Its birth corresponds with the publication of the book *The Theory of Games and Economic Behaviour*[2] (Von Neumann and Morgenstern, 1944) that provides its cultural framework and essential formalization. Nevertheless, the first theorem ascribable to Game Theory was developed in 1913 by the mathematician Zermeno who stated that in every game in which (1) there is the presence of at least two players (2) who can observe reciprocal moves, and (3) alternately play their turns without (4) influencing the decisional system, represents a game in which at least one of the players owns a strategy to reach victory or draw. The following step occurs with John Nash who, during the 1950s, introduced his solution system that would be recognized worldwide as *Nash Equilibrium*[3] (Nash,

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1 Nash, J. (2008) Interview with Piergiorgio Odifreddi, John Nash tra genio e follia, in *Repubblica, Espresso, Cultura*, March 11ᵗʰ.

2 Some important pioneers are Cournot (1938), Edgeworth (1981) for what concerns economic-agent behaviors and Darwin (1881) for applications regarding evolution theory. It is important to remember also a previous text by Von Neumann (1928).

3 A Nash Equilibrium for a game is a set of strategy (marked with the superscript *e*) that is: Ui (se1, se2,…, sei,…, seN) ≥ Ui (s1, s2,…, si,…, sN) for every *i,* and every strategy *s* chosen by the single player *i*.

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1950b, 1951). The American mathematician prompted a research program called *Nash Programme*-that aimed for creating a link between *cooperative* and *non-cooperative games[4]*, and for tracing back the last to the first.

From this starting point, in the last thirty years, GT further developed and enriched with a theoretical *corpus* that takes into account multiple disciplines (Aumann, 1987). Indeed, even if its origin is related to war and financial applications, we can currently find interesting implementations in fields such as political and social sciences, IT, biology, and not the least architecture.

In 2006, Winy Maas- professor at the Berlage Institute/TU Delft, and founder of the architectural firm MVRDV-published the book *Space Fighter*, which triggered reflections upon the *Evolutionary City*: a city that is constantly taking shape and is the result of processual changes in urban planning that tend to the progressive enhancement, adaptation, and optimization, of human/economical/resources management systems. After tracing the origins of Game Theory, if we want to create a deep connection between games and architecture, we have to deal with one of its most useful features-that if analyzed and understood can be turned into design and research components. We are talking about: strategic interactions.

Strategic Interactions: Tools for Emergent Processes in Informal Situations

Game Theory studies the so-called *strategic interactions*: situations in which distinct *players/decision-makers* (individuals, organizations, NGOs, IT systems, etc.) interact with each other to obtain a maximum *profit* through their actions, and to have a positive behavior in the results of the interaction itself. The primary field of application and study of this discipline are those games where the players act in a *strategic* way; to mention that their and the other players' actions directly affect the outcomes of the game. The target of GT is dual: on one side, it aims for organizing our knowledge around a specific class of phenomena (it works, indeed, concerning typing); on the other hand, it tends to raise our awareness to make these phenomena communicable and foreseeable. Therefore, it makes use of a *reductionist[5]* approach where the details of an event are not considered in order to focus only on its fundamental features through operations of abstraction and systematization. Within this research, it is possible to identify two macro-areas: the *non-cooperative Game Theory* - which suits best a strategic decisional approach-and the *cooperative* one, primarily used for splitting up of values and resources inside groups of people. Our interest is pointed towards the use of GT to simulate emergent decisional processes that can structure, and shape, the governance of cities where citizens experienced the lack of centralized governance, like, Tirana and the subsequent social/conflictual dynamics triggered by this situation.

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4 Cooperative games are the one in which there is a chance for the players to establish binding agreements. On the contrary, in non-cooperative (or competitive) ones the players cannot have any pact (even normatively), regardless of their objectives.

5 In epistemology the term *reductionism*-refers to any kind of sciences, which states that every being, methodology and the concepts related to this have to be reduced to the lowest, which is sufficient to explain the facts of the theory in question.
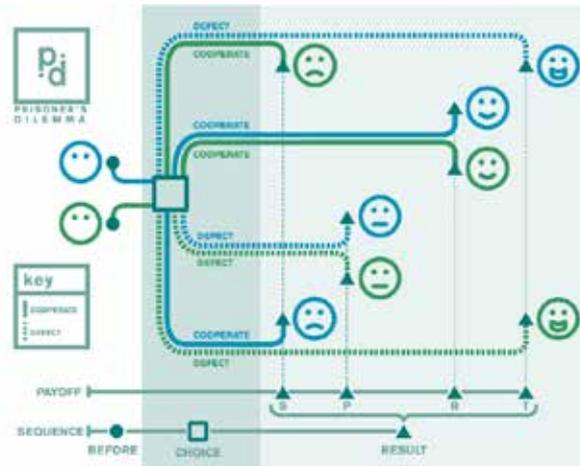
Figure 2: Jon Jensen, C. X., Riestenberg, G. (2012) Infographic that shows all the possible combinations to reach a 'Nash Equilibrium' in the Prisoner's Dilemma (1950), a typical example of non-cooperative game.

Moreover, through the use of Game Theory, we can shape models (Saggio, 2007, 2013) that simulate self-organized biological groups where the analogies between complex urban systems, the biological ones, and the simulations themselves, allow the use of non-standard research methods. These through the appropriate abstraction level, can structure useful invariable systems to operate results' movements in heterogeneous disciplines. In architecture and urban planning as well, we can find a useful implementation of this theory to generate new thoughts regarding the management of participative methods and dynamics, that shape bottom-up processes where the decisional phase is not subordinate to unilateral top-down influences, but also has to take into account the infighting and unpredictability of the many players/agents involved.

Following Michael Batty[6], we are far from the idea of a city as a machine, submitted to a mechanical logic where there is a unilateral correspondence between past and future events, and we are approaching one that is more and more similar to an organism. This is a complex system, neither abstract nor isolated, that acts in relation with the external agents, which hit it, and modifies and shapes itself in different time intervals activating moments of adaptation and innovation. For these reasons, and the unique situation, of the city of Tirana in the following path we will start with the definition of a Game Theory-based strategy to solve the multiple issues of the city's informal settlements development. This paper aims for starting the identification of a positive genome in the urban fabric DNA and for using computational tools to shape a model able to foresee and offer a concrete solution to steer-holistically and systemically-the future growth of the Albanian Capital.

Simulating Emergent Processes in the Urban Environment: Netlogo and the Prisoner's Dilemma

It is possible at this point to simulate processes able to allow the emergence of an urban form of organization, where the centralized control is missing. These simulations can be considered an ideal representation of self-organized biological processes where the rules that control the biological behavior can be used as a set of rules for governing the simulation. A research direction of applying the simulation of emergent processes to the city can be represented by the previously mentioned approach of Winy Maas of MVRDV and the Delft School of Design in the already mentioned book *Space Fighter, The Evolutionary City (Game)*. Their city, mimicking the biological evolution, is opened towards the process and to continuous improvement, optimization, and adapting to ever-changing conditions. This city is governed by a software-controlled extensive database and the democratic participation would

6 English urban planner and geographer, founder of the *Centre for Advanced Spatial Analysis*, founded in 1995.

allow the emergence of a hierarchical structure not administered by planning specialists but by every inhabitant becoming a "city maker".

The role of the architects and city planners would be in this case the interaction with economic, demographic, and informatics fluxes. SpaceFighter creates in this way a platform able to simulate complex behaviors of contemporary settlements thanks to the interactivity and competition of different stakeholders or players. A more radical research direction can be undertaken if the mediating role of the platform that manages the large database of fluxes and conflicting players is not foreseen in the system. If the simulation is based on the competition of rational agents on a territory, the Game Theory can be one of the most useful frameworks for developing the simulation. Not by chance, but the origins of Game Theory can be related to the 1944 work of John von Neumann and Oscan Morgenstern, Theory of Games and Economic Behavior. Even though von Neumann was mainly interested in unravelling how to create winning strategies for competing games like Poker, he manages to create a method for measuring the fitness of complex systems. By introducing the concept of fitness of a system, it is then possible to look for ways of improving the fitness and so making the whole system evolve.

John Nash who was granted the Nobel Prize for Economy, in the definition of his famous equilibrium, states that in the case of the Prisoners' Dilemma, the equilibrium is reached if none of the prisoners collaborates. If the two players collaborated, the gaining would be highest for both, but the risk of the collaboration is to lose everything if the opponent defects. For this reason, economy wise the most rational behavior would be not to collaborate. This situation is commonly imagined in conflict situations where the authority is missing.

In a more realistic situation, the complexity of the system would be higher. It is rare to have real-life events in one-time interactions. When we consider a physical territory, it is common to have repeated interactions and negotiations among the same people. The iterated games would represent a more advanced model of real-life conflict situations. In repeated sets of Prisoners' Dilemma, it is possible to build up strategies based on the moves of the opponent.

Robert Axelrod, known for his work on the evolution of collaboration using Agent-Based Modeling, organized during the '80s a series of Prisoners' Dilemma tournaments where different gaming strategies competed for 200 times among them. The winning strategy was proclaimed TIT FOR TAT, which starts by collaborating and then copying the last move of the opponent. In few words, in this strategy the competitor starts by being good and continues to play fair if the opponent does the same. It defects when the opponent defects. By being kind with who is kind and by opposing who opposes you, Axelrod claims that the system can have the highest gain (Axelrod, 1984).

Chris Adami uses evolutionary principles for selecting ever better competing strategies. After each generation of competition, only the best strategies are selected for the next match, allowing a progressive improvement of the fitness of the system. One of the most interesting emerged strategies is "Win-Stay-Lose-Shift" (WSLS) which makes the same move for as long as it is winning and changes it when it losses (Adami & Hitze, 2013). The 2005 winner of the Nobel Prize for Economy, Robert J. Aumann gave an essential contribution to the better understanding of the conflicts and collaborations through the repetitive games. Aumann states that genetic and memetic evolution brings to a strategic equilibrium and behaviors like altruism, cooperation, trust, and revenge emerged thanks to the repetition of games during the centuries (Aumann 2005).

It is essential to understand at this point that collaboration is not associated with any ethical attributes. The partnership is not to be imposed in this case by any higher authority but it would be rational and profitable for the individual agent and the whole system to collaborate. Some of the features of the iterating game system can be observed through the PD Basic Evolutionary in NetLogo[7]. The simulation

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7 NetLogo is a multi-agent modeling environment based on the Logo programming language (Wilensky, 1999).

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creates a complex system where each agent that occupies a pixel of the lattice representing an abstract territory plays the prisoners' dilemma with all its neighbors and learns from its surroundings.

The agents change their behavior after each generation based on their own and the neighbors' experiences. There are only three simple rules of the game: 1. the agent chooses to collaborate or defect (blue for collaborating, red for defecting, green and yellow for changing behavior during the last generation), 2. During each generation each agent plays a prisoners' dilemma with its eight neighbors having as turn out the average of the turnouts of each game, 3. Each agent adapts in the next generation, the best strategy used by its neighbors. The unique controlling parameter of the system is the ratio between the prize gained by collaborating and the prize acquired by defecting. It is noticeable in images 3 and 4 that the gaining by defecting should be at least 1.6 times bigger than the gaining by collaboration for the system to have a defecting majority; otherwise, the collaboration emerges. It is this ratio that acting as an incentive takes the role of any moral or state authority in allowing the emergence of cooperation and managing a complex and otherwise unpredictable complex system.
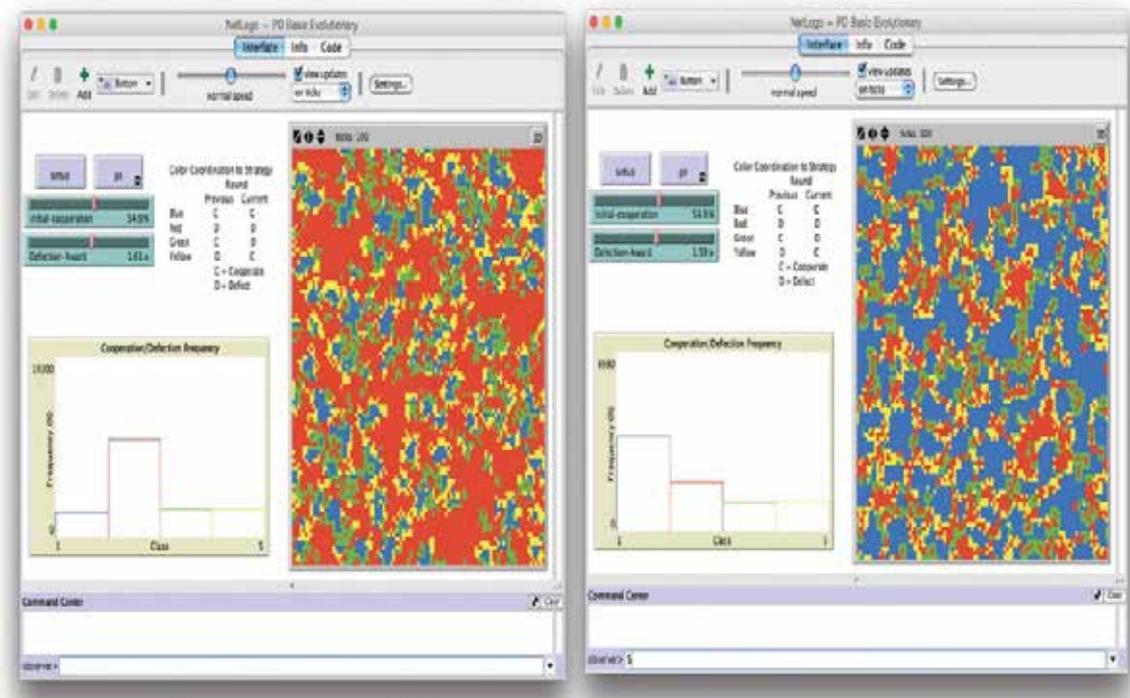
Figure 3-4: Netlogo simulation of the prisoner's dilemma. The agents change their behavior after each generation based on their own and the neighbors' experiences. In this first simulation we can see that the gaining by defecting should be at least 1.6 times bigger than the gaining by collaboration for the system to have a defecting majority Author-Ledian Bregasi.

The second simulation in NetLogo introduces the memory in the system. The agents do not behave following the best possible strategy of their neighbors but remember some past generations and choose the best among them. It can be noticed in images 5 and 6 that systems where the agents remind themselves of more than 50 previous generations, tend to collaborate more. This system managed to evolve not only by mimicking the behavior of the neighbors but learning from its past. It is important to state that collaboration is not necessarily a value per se, but in all cases, the net worth of the system was higher where collaboration emerged.

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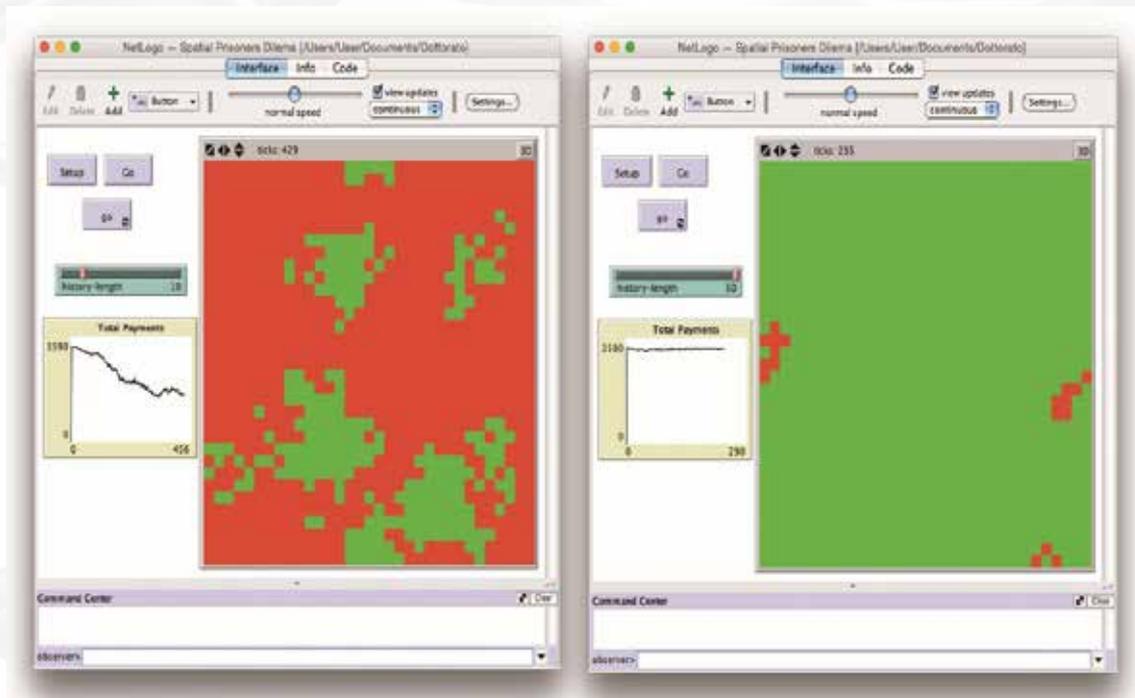
Figure 5-6: In this second simulation memory is introduced within the system. The agents can remember some past generations and choose the best among them. In the pictures above we can see that, introducing this new parameter, agents tend to cooperate more. Author-Ledian Bregasi.

It can be stated at this point that when dealing with complex and interacting systems, such as contemporary cities where it is impossible for a central authority to control every aspect of the urban development, incentives and continuous interactions between the inhabitants can enhance the emergence of collaboration and self-organization. Most importantly, systems that can remember and learn from their past can better organize and adapt to ever-changing environments.

Computational Design to Inform Qualitative Urban Development: Further Steps of a Research

As a starting point to explain our design proposal, we firmly want to detach ourselves from some previous computational design researches that took into account only quantitative parameters in the algorithmic process. We must highlight this difference because we believe that to positively inform the future urban development for the informal areas of Tirana-and to abandon the old-fashioned mentality lying behind urban planning approaches-also qualitative features of the urban fabric must be understood and inserted as variables within a digital process. For this reason, our data analysis is rooted in a thematic analysis (TA) framework (Braun, Clarke, 2014).

According to the authors, with this methodology, we refer to a way for systematically identifying, organizing, and offering new research insight into patterns of meaning (themes) ranging across a set of data. Furthermore, TA allows the researcher to identify and critically organize collective or shared meanings and experiences. The primary aim of TA is not to identify unilateral and unique meanings within a single data item but make sense of the commonalities found in heterogeneous data sets and to isolate the ones that can be interrelated to answer a specific design and research question. The main strategy for our experimentation would be then to start by identifying the gene of its 'cell' referring to the studied patterns of Tirana.

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Through these studies four main patterns have been analyzed, each referring to a moment in the growth of the city and each harboring in themselves a different set of parameters and different 'genes'. Each of those can be used to identify the oldest gene or the starting gene that has directed the growth of the other settlements. As stated by Sotir Dhamo (2017, 2021), most of those transformations and additions over time highlight a system of growth based on the self-similar and self-affine, meaning that the original cell or theory, the current condition informed by the original cell be used as the starting point of the game.

Seeing as this is research-based on both quantitative and qualitative/perceptive data, all these need to be translated into parameters that will influence the way the generative system behaves. Spatial qualities and the parameters related to the spatial attributes would play a central role in the spatial result of the generative algorithm. As actors play, their space changes according to decisions that they make and these changes need to be following minimal spatial and architectural parameters. All parameters will be deduced by comparing spatial typologies of current and historical structures. This outcome could be achieved by using metaheuristic search algorithms to discover novel and high-performing results within a given design system. Its framework is based on three main components:

- a generative geometry model that defines a 'design space' of possible design solutions;
- a series of measures or metrics that describe the objectives or goals of the design problem;
- a meta-heuristic search algorithm such as a genetic algorithm which can search through the design space to find a variety of high-performing design options based on the stated objectives.

Since the main aim of GT is to study strategic interactions, the so-called players/decision-makers that make these decisions are to play a central role in the generative process. So actors, citizens, local governance, stakeholders, etc. themselves can be the players/decision-makers of the game. Each of them would have specific rules and limitations according to their role in the game, a position that also defines the goal. Seeing as we are talking about a non-cooperative GT each of their goals is individual. More than one of each actor can be part of the game, allowing for a more complex and better-fit result by introducing more parameters and iterations.

Furthermore, Mitchel and McCullough (1991) have identified the role of generative design processes early on and stated that computational design processes are able to address a level of complexity of parameters and interactions much higher than what the average human cognitive process can handle alone. They continue however by saying that instead of promoting "automated design procedures" there should always remain a central role for the designer's intellectual capacity, using his critical judgment towards the writing or application of the algorithm, the input of data parameters, and the definition of evaluation criteria. Generative design in this context is proposed to operate on the relationships rather than on formal characteristics of the built environment.

As per the statement of Michael Batty and following the studies of Tirana and its informal areas' development, and since Tirana represents in a lot of different ways a complex organic system, it is only normal that an approach to a generative system should shy away from just the spatial approach but should instead work on all the underlying parameters that need to be discovered that give shape to this complex system. Using non-cooperative GT as a way to introduce actors into the generative system and give them the possibility to influence the system and outcome directly would be a different and innovative way of city making.

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Conclusion and Future Steps

The next challenge for our research will be focusing on demonstrating how "traditional"-and quantitative-methods for planning urban processes can comfortably coexist, and thus be enhanced, by the use of interdisciplinary tools such as computational design tools, digital media, and gamified citizens engaging system to interrelate multiple sets of different data. The city making process we refer to is the one where the design phase is human-centered (Ferri, De Wall, 2017) and takes into account also needs and the desires of all the stakeholders involved in the evolution of the city. As pointed out in many recent pieces of research (Ampatzidou et al., 2018) three main perspectives can be considered as benefits for participatory processes implementing Game Theory and playful applications: 1. The possibility to illustrate complex urban issues and make the complexity more tangible, 2. The idea of evoking social learning and capacity building, and, 3. The chance to make the participatory processes 'lighter' and easier to attend.

Our aim with this paper was to set the base for a quantitative/qualitative analysis to understand better the peculiar generative patterns that coexist in the kaleidoscopic urban fabric of the Albanian capital of Tirana. As a next step, more on-site testing and validation are certainly needed, and we see this process as inherently iterative, incremental, and practical. We are conscious that there is much work to be done, but also that the potential of this approach is far from being exhausted. For this reason, the next step will consist in developing the design algorithm-actually scripted using Rhinoceros' plug-in Grasshopper-and later applying it to a chosen informal area of Tirana to test, and eventually, re-shape, the categories we have been using in this paper as an analysis tool.

The upcoming algorithm will be shaped following both a quantitative set of parameters-to optimize the physical need of the dwelling such as sun enlightenment, private/public delimitation, etc., and also a qualitative one to take into account different inputs and try to develop a tool to lower the social conflicts that characterize the urban development of the informal city and set a positive research agenda to inform the future development of the city's more problematic area. There is much work to do, and we surely need more complex data analysis and real-case experimentations, to set an ever-growing design-oriented dialogue that can lead to further implementations and follow-up studies.

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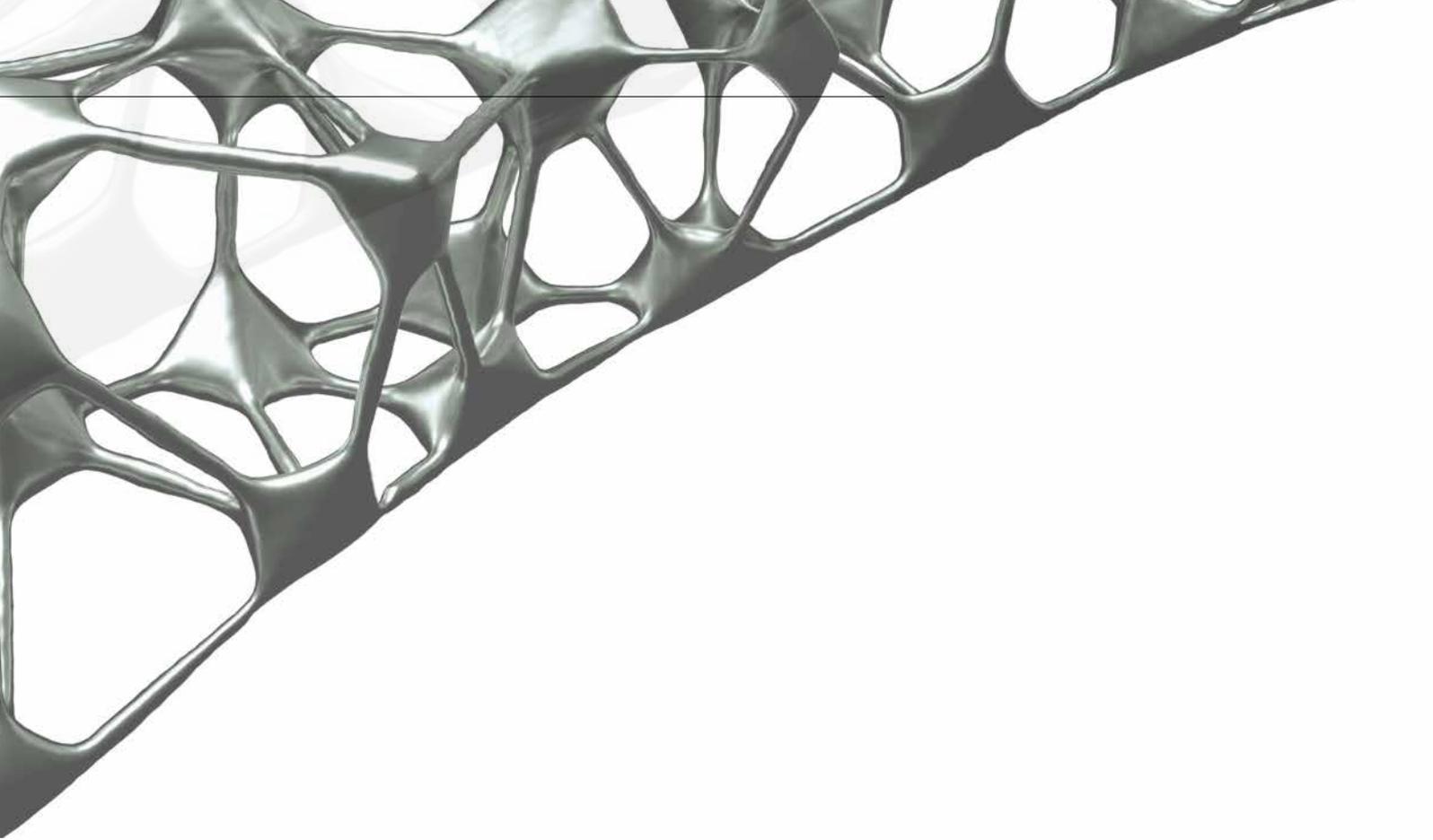
Part II: Keynote Speakers' Essays

Reconstructing Identities and the Idea of Global Regionalism

Ali Mangera

MEng Dip Arch RIBA, Director MYAA

AM@myaa.eu

We live in a time of great anxiety and change; a time of shifting allegiances where the certainties upon which we have relied have simply vanished. Our once familiar political landscape is in flux; pandemics, civil rights, China, Brexit, Trump, interminable wars and nationalism, have led us to seek answers in ways that are simple and easy to understand. The fingerprints of identity politics are everywhere.

Whilst we come to terms with new 'facts on the ground', we have also come to the realization that our towns and cities are unable to cope with demands we have placed upon them. Urban ghettos, characterless neighborhoods, and gated communities are fertile ground for a Parisian 'gilet jaune' protest. We have through our own actions become complicit in the demise of our cities and the place we call home.

In *The Death and Life of Great American Cities (1960)* Jane Jacobs illustrates how poor planning led to the marginalization in our cities, dividing communities and creating blight which has now become a common trait in cities around the world. Despite acknowledging our failings, cities have continued to converge into a ubiquitous urbanism where the unique qualities that make cities individual and provide character have been expunged in the name of efficient planning. Our dystopic vision illustrated long before in Charles Booth's 1886 poverty map of London entrenches inequality by partitioning the city into areas varying degrees of affluence and poverty.

Ubiquitous urbanism ultimately leads to greater and greater convergence, which is why retail malls in any city sell the same branded goods behind the same shopfronts to the same demographic. Cities have been emasculated by the needs of global capital and our desire to seek an homogenized and sanitized view of ourselves. But the uniformity that we both seek and impose on the world has also left us disappointed and confused.

Our reaction sometimes calls upon an inner nostalgia; to long for a time when things were simpler. A time when our cities were less structured and less controlled.

An obvious panacea was the postmodern movement which offers the wholesale resurrection of a fictional past omitting the Dickensian squalor for an eager public. And by coincidence or design, the fakery implicit in postmodernism has parallels with fakery we have now come to accept in our political life while the public remain oblivious.

The Prince of Wales's Poundbury estate may be seen as a successful example of an idyllic rural townscape from a bygone era but through its formal gestures, it also reinforces the idea of the British aristocracy complete with its social structures.

The idea of transplanting the past into the present has also given shape to countless real estate projects globally but in the Arabian Gulf this approach describes whole swathes of cities which give rise to branded neighborhoods such as Villaggio in Doha, or Arabian Ranches in Dubai. No longer do we need to visit historic Europe, we now have the means to recreate it on our doorstep. Fake cities in the guise of Venturi- Brown's (1972) *Learning from Las Vegas* or Hobsbawm's (1983) *Invention of Tradition* predate our recent obsession with fake news but the Disneyification or more appropriately, Dubaization as Elsheshtawy (2004) describes it continues apace.

Into this backdrop, we have seen valiant attempts to change the dynamic and to provide an alternative,

which is less Euro-pastiche, and more related to what Frampton (1981) calls *Critical Regionalism*. Critical regionalism questions the orthodoxy of the 'international style' and its tendency to provide soleless cities lacking identity, yet its approach is intrinsically modern and contrasts with the smoke and mirrors of postmodernism. Critically regional architecture was already present in the modernism of Le Corbusier's Ronchamp and it represents the triumph of contextualism over the dogma of simplified modernist ideology. But Frampton (2018) himself seems to go one step further in 'Beyond Critical Regionalism' claiming that there is a political dimension to regionalism; *'it has a lot to do with local identity, the effort of decision making and the local domain on the territory, which some people are over-concerned about. This is the context in which the theory can still be considered effective today'*

Koolhaas's 'Generic City' by contrast claims we are in a progressive stage of losing identity through homogenization where architecture is reduced to functional objects or that "*If we simply let cyberspace run its course to a future determined by Silicon Valley, those libertarian-minded engineers will paradoxically lead us to cities shackled by algorithmic conformity. It would be a neural network, yes, but one that operates in lock step*."

MYAA's approach to architecture can in many ways be considered as critically regional but not in the way Frampton sees it. Our view mediates a space between the fait accompli of the global city and the need for regional architecture; perhaps a new kind of *'global-regionalism'*. To achieve this we use all modes of production from socio-cultural analysis, big data and parametrics through to buildings made by hand. We are of course aware that the proliferation of global culture and ideology creates winners and losers, but its presence for good or for bad is inescapable.

The question we must also ask is 'what is regional?' when the idea of region in both space and time are fluid. Is 'regional architecture' pre-colonial or represented by the bounds of a Nation State and if so, which period should we consider? Is Geoffrey Bawa's work in Ceylon 'regional' and should a European man be empowered to decide what is regional architecture for Sri Lanka. And in the case of The Arabian Gulf, should regional architecture be inspired by The Nabateans of the Levant or the Ottomans, Persians, or Bedouins and what is the limit of our territory?

The needs of global capital has given rise to global culture which in turn has led architecture to converge around ideas that are generic and risk averse. In contrast, the architecture of global regionalism cannot be seen simply in a formal sense but rather as ideas that question accepted notions of territory and region, or how buildings come into being, how they are used programmatically and how they adapt to meet the challenges of their unique socio-cultural context.

Where the 'international style' bluntly impose solutions upon the city and where postmodernism reduces the city to a caricature, global regionalism must be provocative, sensitive to context whilst remaining conscious of patronage.

We recognize also that architecture can never escape its political purpose; from the Great Pyramid of Giza to Mussolini's Palazzo della Civiltà Italiana; or China TV's polished headquarters, all buildings regardless of scale are a manifestation and projection of our beliefs and our anxieties.

Using tools that are available to us, MYAA attempts to create architecture through cultural layering, whilst we question the orthodoxy of existing building typologies. In so doing, we do not subscribe to the singularity of context; it is both necessary and important to create the context into which architecture resides if only to pose questions and to facilitate new forms of spatial organization. We are aware also of our limitations; namely our ability to convince developers and governments to invest in ideas that challenge the status quo.

By way of example, MYAA's Faculty of Islamic Studies on the Education City campus revisits theological pedagogy and creates a new dynamic between learning and praying space. Based on a spiral

plan, the scheme suggests an interchangeability between gaining knowledge (academic space) and seeking enlightenment (praying space). In terms of form, outwardly and by way of gesture, the scheme presents Islam as a faith that both embraces and projects contemporary society. But its form is also related to climatic conditions which led us to carve out cooler shaded areas that create microclimates whilst also inviting visitors from the campus through pathways that facilitate contemplation.

The building is layered with meaning and interpretation; its shaded undercroft is created by the five pillars of Islam that elevate the prayer space above. Qur'anic verse is applied to the buildings fabric so that the building can literally and metaphorically be 'read'. The landscaping incorporates a four-part Islamic garden with rivers of paradise defined by scripture. Our approach provides a basis for exploration and discovery rather than giving simple answers to complex questions of faith.

In London, we are currently working on a Cultural Centre in Harrow; a multifaith community building funded by East African Asian migrants that have settled in the UK. The story of the ancestral journey of the client from Persia to India, then to East Africa and eventually to the UK is described through an ornate patterning on the skin of the building. But the idea of patterning is not whimsical. The site is located in the heart of what John Betjeman calls Metro Land, an area that was influenced by the work of William Morris and the Arts and Crafts movement. Morris was by coincidence greatly influenced by Islamic geometric patterning and his work can be seen as a synthesis of both local and global in the arts and crafts tradition.

Our horticultural school in Rabat is built on a former municipal dumpsite on the outskirts of the city. The dumpsite contaminated the local watercourse and blighted neighboring communities whilst also emitting large quantities of landfill gas. The municipality introduced a biogas capture facility; the first of its kind in Africa, capturing 250,000 tons of landfill gas and providing energy for 5000 homes whilst reducing greenhouse gases. The low budget building is clad in hand-made clay bricks use traditional construction techniques. The scheme is certainly not an iconic building, but it does connect with context through its materiality and its community engagement. And its earth walling ensures the school remains cool over the Rabat's hot summer months

In Madagascar we worked on an Academy and a Galleria building which are inspired by the Malagasy tradition of pointed roofs. The building's metallic skin also incorporates a pattern from the Malagasy Fanorona board game in the spirit of the local Zafimaniry wood craft tradition

And in Barcelona we are about to start work on the city's iconic cathedral; a building that is symbolic not only in terms of architecture but also in terms of its significance to Catalan independence. As Frampton suggests *'In Spain, there is a request for direct democracy. So I think there is an aspect of Critical Regionalism which has a kind of political dimension, it has a lot to do with local identity, the effort of decision making and the local domain on the territory, which some people are over-concerned about.*

It is too early to say how our work in Barcelona will materialize but what is clear is that the project will harness new and emerging technologies that will be co-opted to address the needs of both a global and regional audience.

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Crossing the Rubicon: Tevere Cavo, an Urban Project for Rome

Antonino Saggio

Diap "Sapienza" University of Rome

antosga@gmail.com

Abstract

We believe that the new frontiers of Information Technology have to deal with the central role of Infrastructures in the existing city. Indeed, this new generation of infrastructures will allow the 'redirection' of the development. To arrest developments in "Green fields" and direct developments towards "brown areas" in the existing cities we need infrastructures of new generation. In this historical moment, a development phase has to focus on the use of urban voids in the existing city to stop the endless urban sprawl. 'Crossing the Rubicon' was an expression I used years ago - in the preface of Kas Oosterhuis's book "Towards new Architecture" - to underline the role of a generation of architects that put Information Technology at the heart of a new development phase for architecture. I am using the same expression now to highlight the role that Information Technology has to play to shape new infrastructures. As an example, here I present and discuss the urban project "Tevere Cavo" in Rome.

Introduction

Tevere Cavo is the name of an urban project developed between 2012 and 2018 – in the Faculty of Architecture at 'Sapienza – Università di Roma' – within the university chair of Antonino Saggio.

This project involved Ph.D. students, graduating and senior students, in designing almost three hundred projects for the northern sector of Rome, which is marked out by the presence of the river Tiber.

The design proposal sees the river Tiber as a new generation infrastructure based upon five essential principles ranging from multi-functionality to ecological systems, from mobility to information networks, up to the relaunch of the civic and symbolic role of the infrastructures to foster interventions in the built environment.

In this way, the river acts as a fly-wheel to invert the direction of the development, shifting from the constant erosion of the agricultural land to the rehabilitation of small and significant abandoned urban areas.

For further details and the extensive related bibliography, for access to the maps that guided through the work, and for the many lectures, please refer to the official page of the design proposal:

http://www.arc1.uniroma1.it/saggio/TevereCavo/

Rome: Two Foundings one Tiber.

The project 'Tevere Cavo' profoundly relates to the city of Rome, and Rome displays a peculiarity. It has two origin myths, and both connect to its river, the Tiber indeed.

The first is a pastoral and autochthonous one; it has a damp culture, made of woods, forests, and animals.

Romulus and Remus, sons of rape and abandoned in the water, were found inside a basket in the Velabrum (the swamp area between the Capitol and the Tiber Island) and breastfed by a she-wolf.

The second one is a myth of foreign extraction (anti-autochthonous); this myth is grand and heroic: the light of the fate takes the place of the wood's moisture.

At dawn, Trojans arrived at the Tiber's mouth: defeated indeed, but valiant and beautiful.

In the Aeneid, there is a passage that recalls the docking at the Tiber's outlet: "At this moment, gazing from the sea, Aeneas saw a vast forest. Through it the Tiber's lovely river, with swirling eddies full of golden sand bursts into the ocean…"

Indeed, the more you study ancient myths, the more you find the components of reality. It was thought that the Iliad and the Odyssey grounded in legends, then Troy was conclusively discovered by Heinrich Schliemann. It is a fact – thanks to years of archaeological excavations and Andrea Carandini's scientific work – that the base upon which Rome developed has its roots in the Etruscan culture.

Therefore, do not the two different origin myths regarding the founding of Rome – one autochthonous and the other one cultured and of foreign extraction – clearly explain the marriage that characterizes the Etruscan culture itself?

A culture that does not arrive as pre-formed, but comes into the world following the hybridization between a native culture – the Villanovan one, deeply connected to the earth – and an external that is more advanced in the fields of thought, art, and writing.

THE TIBER DIGS

Rome strongly links to its orography. The city develops on a volcanic area, continuously moving and waving. Volcanoes are within its DNA: from Bolsena, Vico and Bracciano in the North, to Albano and Nemi in the South, large mouths of fire surround the city. It seems to be shaped by lava elevations that draw a shifting landscape, endlessly variable.

Lava's solidification processes – deeply related to rainwater flows, wind, and vegetation – outline the space: the gorges in which water streams erode tuff. In this sequence of movements, and ups and downs, we see the rise of the first villages.

The Tiber is a sort of big rift between lithospheric plates emerged after the drop in the sea level. As much as the fissures, that create within a dry soil. The river, volcanoes and eruptions shape places, and model the renowned hills.

Giambattista Piranesi, in his drawings and etchings, knew how to represent this magmatic nature made of digs, vegetation, and ruins. Piranesi staunchly fights against both the classical and neo-classic Greek myth in favor of a vegetal, stratified, magical, ancestral, and Etruscan, world of Rome.

He repeatedly drew Rome and the Tiber. His drawings are beautiful, touching, and indeed projects 'in fieri'.

Therefore, Rome was born on rough and volcanic soil, its founding relates to two myths that see the Tiber in their hearts, and rooted in the Etruscan culture. Fragment and stratification are present: these are the reasons that set the scene for the 'Tevere Cavo' project. However, why does this adjective, "cavo", appear in the title?

Tevere "Cavo"

The idea regarding the slit in the ground where the Tiber flows is only the first reason why Tevere Cavo (empty or void in English) is the name of the project showed up here.

The second one deals with the 'Vie Cave' or 'Etruscan Tagliate.' Let us try briefly to understand. We have spoken about the articulation of the land and, on this territory; the Etruscan civilization set itself up and developed.

Now, in this land, the Etruscan culture creates a relationship between architecture and environment that cannot be anything else rather than a marriage, a twine between nature and artifact. The section

is the key. However, we do not refer only to an operative process. Indeed, the section and the digging reveal a deeper connection. According to the Etruscans, the Earth is sacred and endlessly sends a message. The Earth 'speaks'.

This relationship wholly reveals itself in the so-called "Tagliate" or, indeed, Vie cave. These are processional paths, dug by men in the tuff even fifteen meters high and for hundreds of meters. Vie cave are the symbol of a holistic approach – or systemic as we would say today – to the topic regarding the relationship between nature and artifact. In these, a set of meanings overstepping mere functional data to insert cultural, symbolic, and religious reasons, condense. What we call 'a road' is, at the same time, a processional path, a celebration of Mother Earth and – functionally and prosaically speaking – a 'quarry' where to extract building material that is used in the construction of temples and most relevant public buildings.

Nevertheless, if we relate with the modern conception of a quarry, and with the Etruscan Tagliata as a proper quarry itself, then we understand the presence of a systemic twine that profoundly inspires us. An action – the digging – made not only for one reason but roundly for many.

Much of our work on this topic cobbles together these ancient echoes - these endlessly recalled 'imprinting' - and the issues related to Information Technology, to develop a critical consciousness that without IT cannot face contemporary crises.

Indeed, if on the one hand, the word 'cavo' refers to the orographic history of the fracture and on the other hand to the Etruscan world, the word 'cavo' also means in Italian electric wire and rope. And a substantial aspect of the work Tevere Cavo is indeed related to the implementation of Information Technology within the Design of new generation.

1. Abandoned or underutilized industrial and productive buildings;

2. Under the viaduct areas, traffic dividers;

3. Green areas and abandon and underutilized river bands;

4. Free areas, build-able but unused lots, unfinished and in the state of abandoned buildings and urban complexes.

5. Areas belonging to public buildings that are visibly under or misused – these include garden, parking lots, storages, schools' common areas;

6. Gas stations and small stores, either still productive or already abandoned.

The areas eligible to these categories have been recorded in a shared map (search for "Tevere cavo" in Google Maps or go to goo.gl/HSmviY). Each of these areas links to a specific record in the designated blog that contains further information regarding the specific area and, above all, the titles and the authors of the different projects proposed for that lot.

Every link progressively leads to the project development. Overall, we are dealing with almost three hundred proposals allocated to approximately 50 areas.

Now, let us see the principles that move a "next generation urban infrastructure" like Tevere cavo is.

Five Principles

As said, infrastructures, whether artificial like streets, highways and railways or natural like waterways and water paths, have always been a fundamental tool for development. They have been the fly-wheel that – in a few decades in XIX century - led us to the doubling, the triplication, and the decoupling of the building stock. But starting on the 1960s of XX century with the crisis of the traditional industrial society and model of production, many industrial areas were abandoned and furthermore the more our cities expanded, the more abandoned areas, empty and dilapidated buildings they left behind.

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As is known, in the current historical phase we entirely have to limit the agricultural soil consumption. However, even though we have to restrict soil consumption, we surely cannot stop the development! The answer to address this topic is simply "to invert the development direction". From the expansion toward free land to the re-use of existing but abandoned or underutilized parts of the cities.

Anyway, to do this and to focus towards the recovery and the usage of urban voids, we need, indeed, new generation infrastructures.

Five fundamental features mark the latter. They have to be *multitasking*, that is doing multiple things at the same time, and active towards the direction of a sustainable development, and able to create *green systems* (specifically not only they do not have to pollute and waste a few energy, but – above all – they have to insert active cycles of decontamination and de-pollution). They have to guarantee quality mobility, which we call *slowscape*, and a vector towards digitization of the city to form an *information technology foam.* Lastly, they have to be able to *galvanize* souls and instill citizens' value in public space.

Multitasking

A new generation infrastructure must be able to carry out multiple functions at the same time, weaving and strengthening them with one another.

The world changes, and in the Third Wave of the Information Society, the idea of multitasking erased the concept of monotasking that belongs to the industrial civilization; the Mixitè erased the Zoning, and the Tablet, coming from the Silicon Valley, replaced Henry Ford's Ford T.

Indeed, one of the most incomprehensible things for one who has never seen a computer is that it can simultaneously do many things and be structurally multitasking. After all, if we had the chance to visit an assembly line in a car factory, we would discover that, also there, the assembly line and the conveyor belt do not exist anymore. What we would find is a sort of neo-artisan that makes all by himself, and that we would call a robot.

Therefore, a new generation infrastructure has indeed to be multitasking like our computers. The new productive models have changed and shaped the city in their image and likeness. If the Zoning represented an optimized monotasking idea applied to the town, today's parallel and coexisting cycles of the IT society go in the opposite direction.

Indeed, the idea of multitasking infrastructures is not new. It only has been erased by the monotasking vision of the world that came with the industrialism. Immediately, our thoughts go to the bridge as a place for commerce and living, as a custom or a market. From Ponte Milvio in Rome to Ponte Vecchio in Florence or Ponte di Rialto in Venice, we Italians have many models to which we can refer.

However, also elsewhere there are fantastic examples of them. In Iran, for example, there is an exciting multitasking infrastructure, the Khaju Bridge, where the dike serves to the bridge, the bridge to the strolling, and the shelters are useful to public spaces. All the Tevere Cavo projects try to be intrinsically multitasking. To make an example, if we have a green area we want this to produce energy and to be an exciting aesthetical and educational space. If we have a sports facility, we expect that the athletes' movement will contribute physically to shape the public space instead of only contribute to the building energy supply. If we design a bridge, this must be a collector for rainwater, a device for air purification using particular algae inserted in the guardrail, and an emitter of information and performances. Moreover, the asphalt has to produce energy through the presence of piezoelectric elements underneath the road surface. Is it not the river one of the most multitasking structures one can think of?

Editorial Note:

The author wishes to thank Dr. Valerio Perna, Lecturer at Polis University of Tirana, for his translation in English of this text.

Key of Images

0 -Tevere cavo overall view Tevere cavo Antonino Saggio Chair project for Rome 2013-2018 drawing by L. Cavallo, G. Rubino and v. Perna.

0a -Book cover "Tevere cavo una infrastruttura di nuova generazione per Roma tra passato e futuro" eds Antonino Saggio, Gaetano de Francesco (Itools-Lulu.com, 2018).

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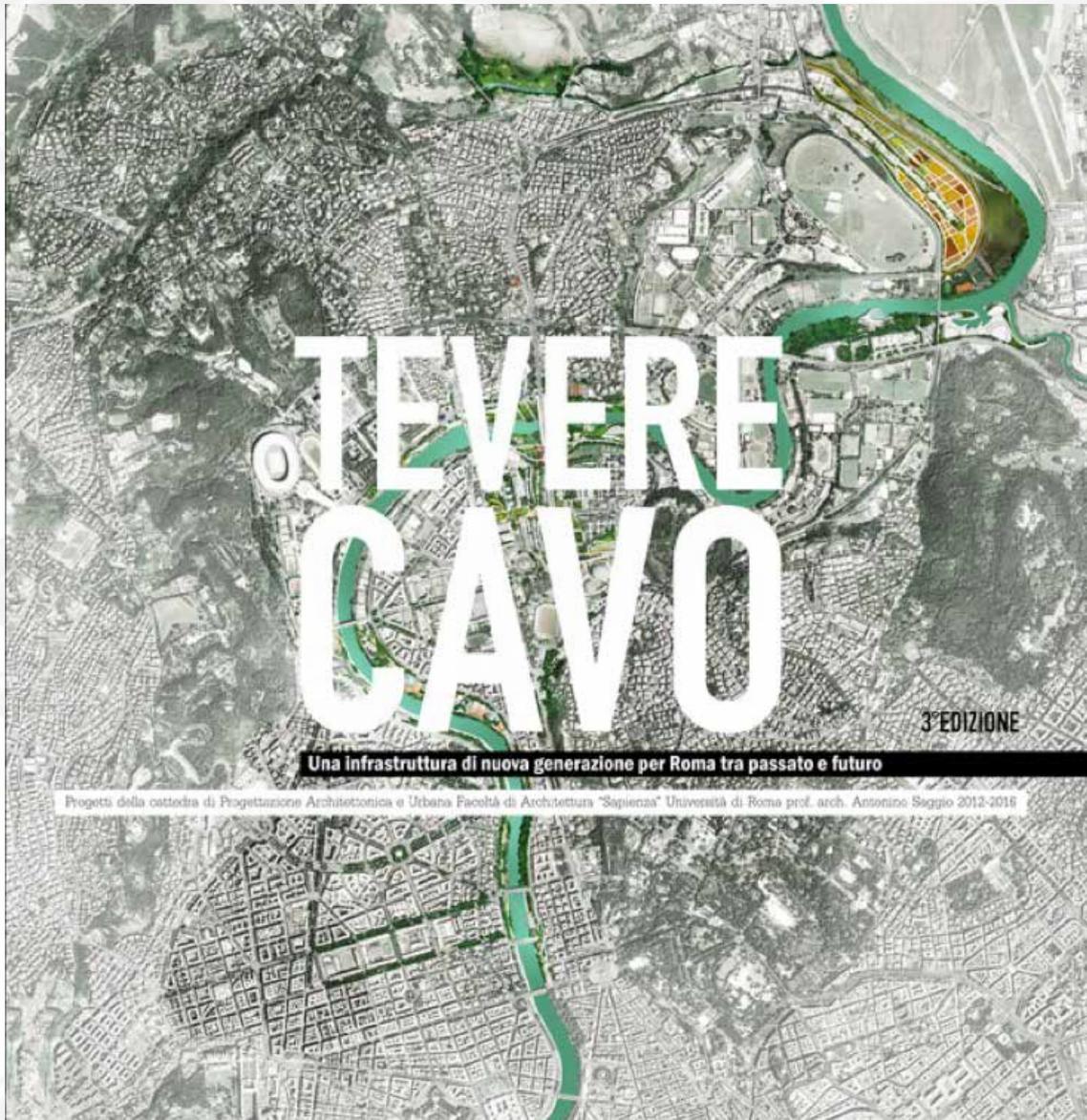
0b- Map of the major projects of Tevere cavi in the map of northern part of Rome.
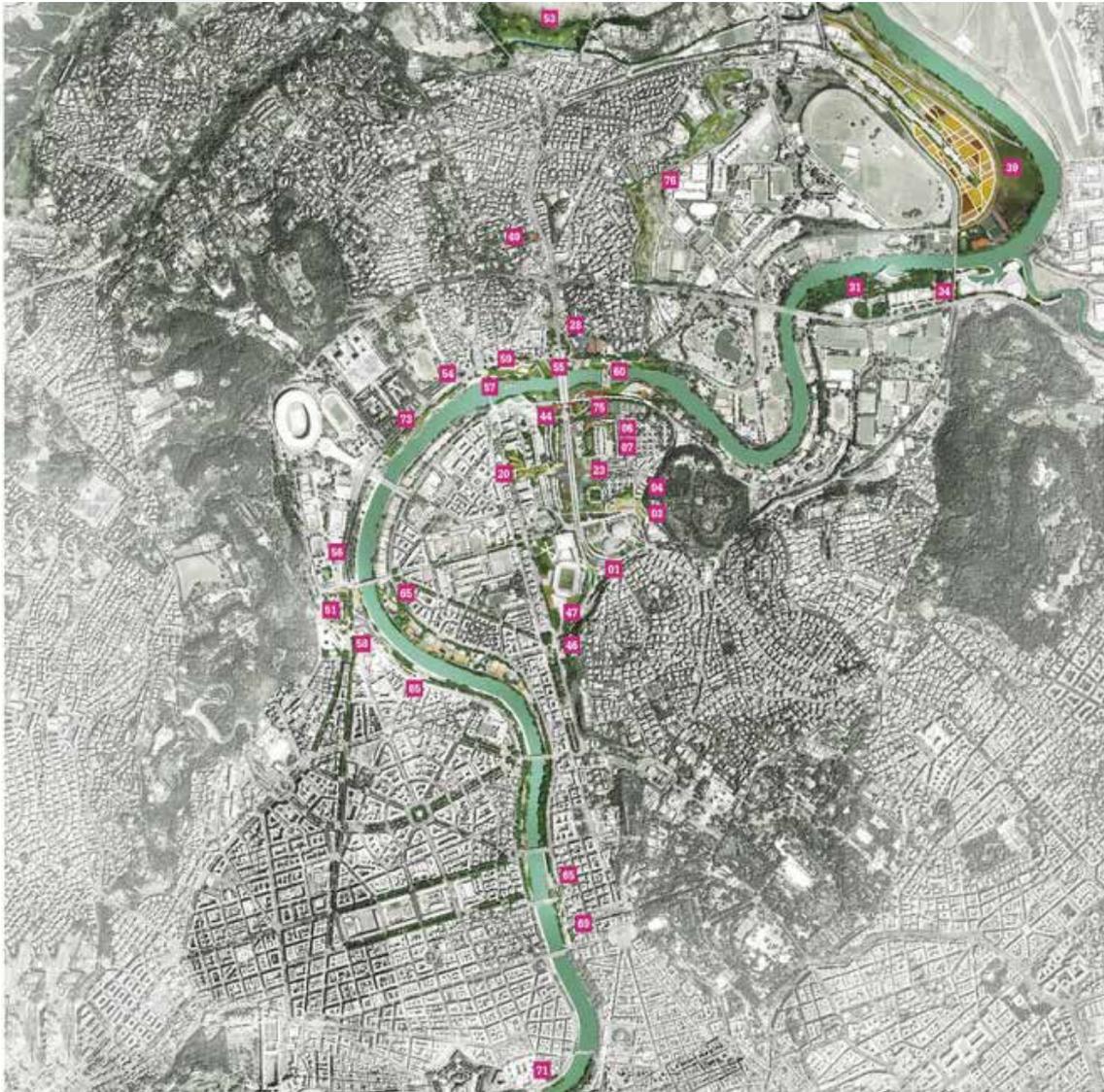
A- Map of the major projects of Tevere cavo in the map of northern part of Rome.

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A0. Site plan Liborio Sforza, "ex.[PO]. A new bridge at the furnaces of Castel Giubileo and technological center for the development of constructive experimentations." Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

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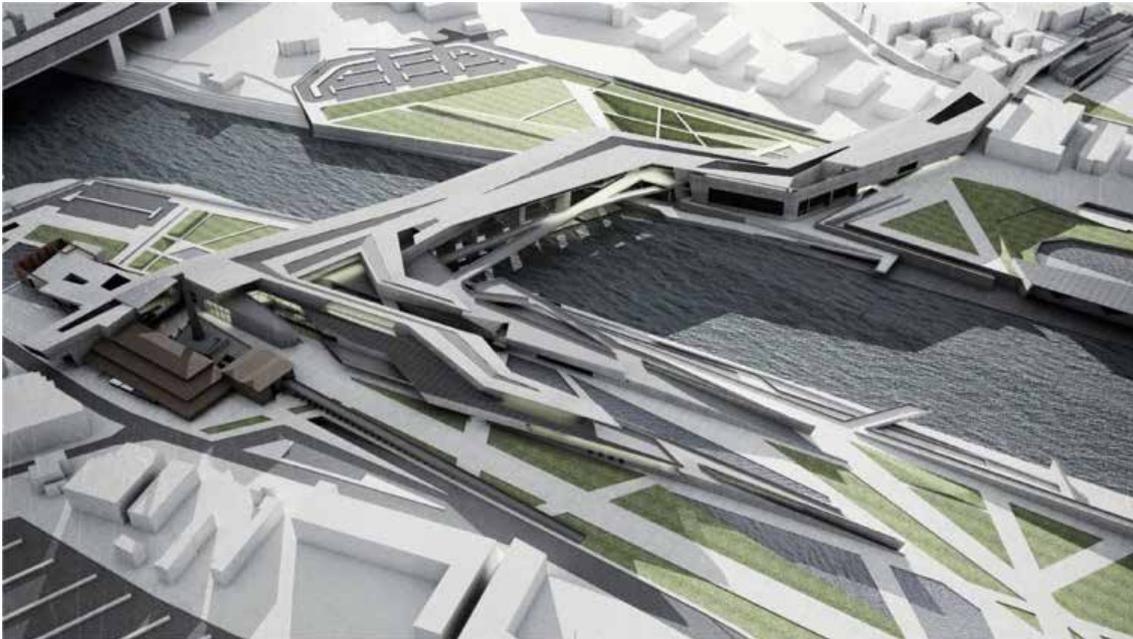
B - Perspective view Liborio Sforza, "ex.[PO]. A new bridge at the furnaces of Castel Giubileo and technological center for the development of constructive experimentations." Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

B0. Perspective view Matteo Benucci, Carmelo Radeglia, Alessandro Rosa, "Logica Eco-Logica. Productive and depolluting park at Inviolatella Borghese." Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

C- Site plan Matteo Benucci, Carmelo Radeglia, Alessandro Rosa "Logica Eco-Logica. Productive and depolluting park at Inviolatella Borghese" Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

Ca. Perspective view Alessandro Perosillo, "Eco District Park: Urban park, industrial district, and center to educate about recycling," Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

Cb. Site plan and views, Alessandro Perosillo, "Eco District Park: Urban park, industrial district, and center to educate about recycling," Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

D. Elevation Alessandro Perosillo, "Eco District Park: Urban park, industrial district, and center to educate about recycling," Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.
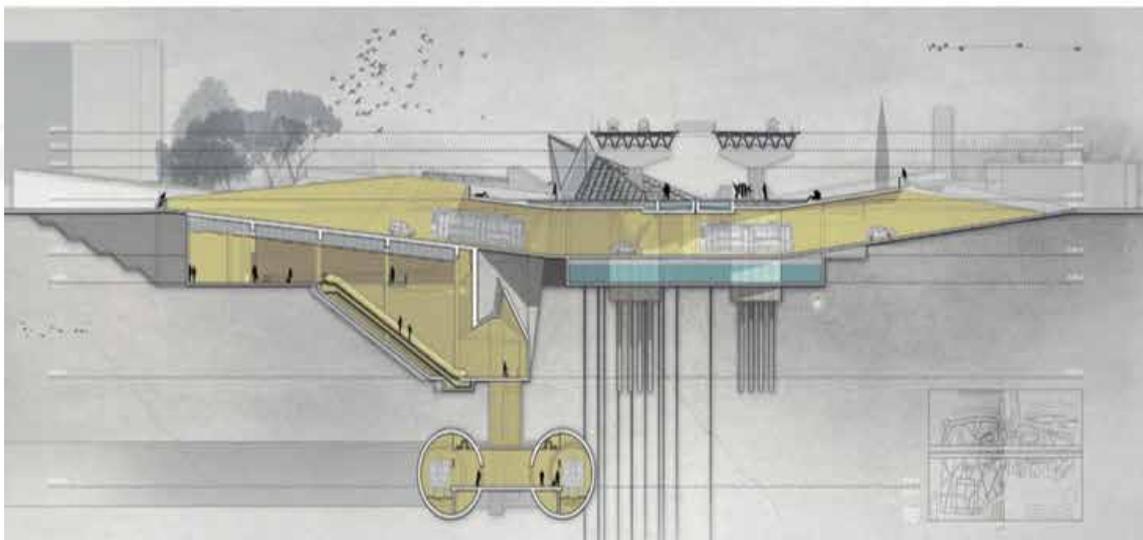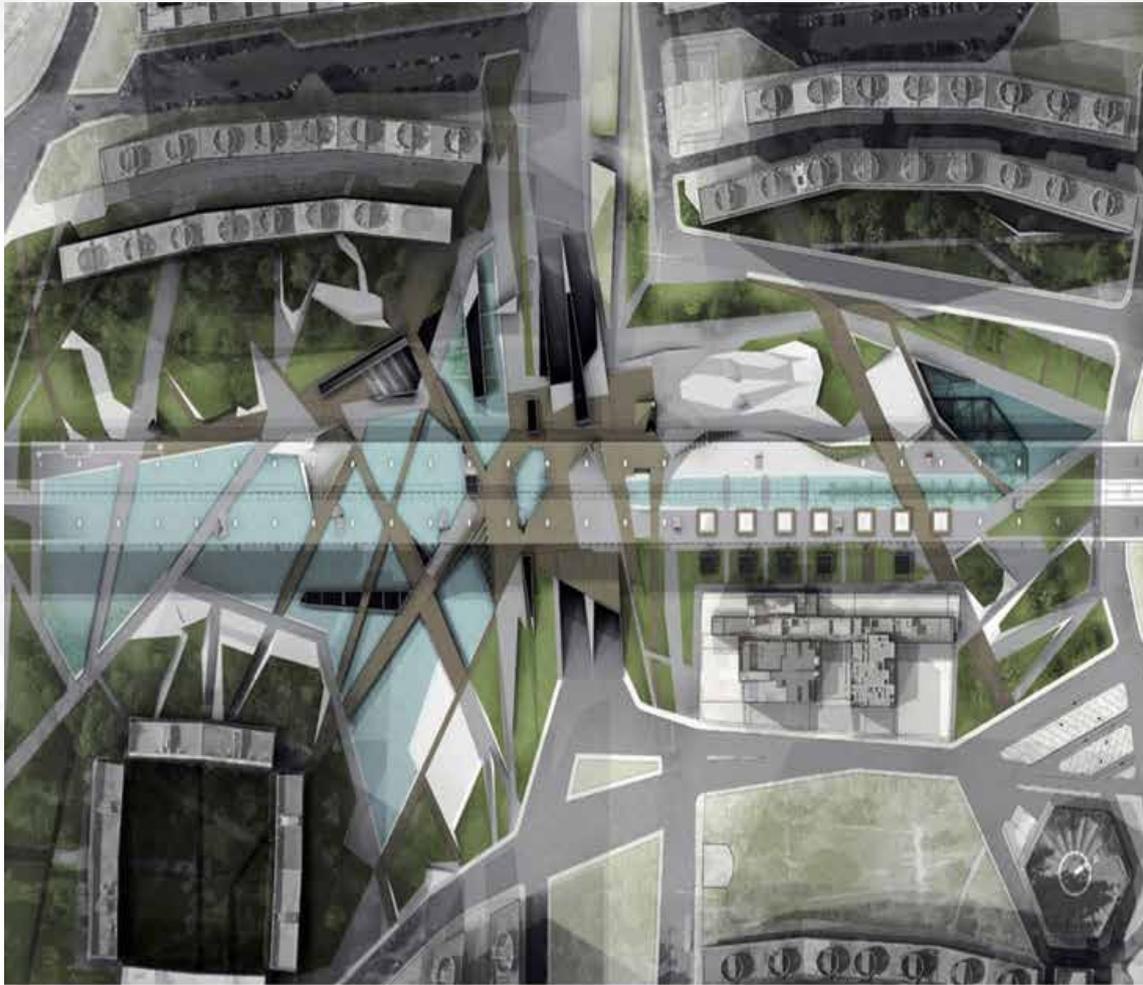
D0. Site plan and section Valerio Galeone, PARK [ing] Hub for the intermodal transportation and bio-monitoring, Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

E. Perspective view Michela Falcone, "Water Playground: Urban happiness system for the phytoremediation and the reconquering of the Tiber," Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

F. Side by side Microprojects on the riverbank of Tevere, Livia Cavallo, Giuseppina Rubino, Silvia Di Marco, Tevere Cavo Antonino Saggio Chair project for Rome 2013-2018.

Medinas: From Vernacular to Smart Sustainable Cities and Buildings

Fodil Fadli

f.fadli@qu.edu.qa

Cities are the most prominent agile and resilient complex systems that evolved over time and space. Many of them survived for centuries, some for more than two millennia, like the **Medinas** of the MENA region, and they are still thriving. They survived many natural and human-made hazards and crises not to mention fundamental cultural and economic changes. Urbanists and sociologists believe that the key to a sustainable agile city is the existence and living of a community with its inhabitants and users. When the community vanishes, and the communal societal spirit disappears, it is only a matter of time before a city begins to decline and potentially fully disappears or mutates. A gradual disintegration of various infrastructure systems and services leads to crime rise, poverty, deficient educational and health systems, and a growing social divisions and inequalities.

While the medina, being the sustainable agile city, is formed and considered as the matrix; the courtyard house or smart home, can be seen as the component-cell. The principles and concepts of smart sustainable cities and structures were adopted in the domestic architectural design for many years and centuries. In fact, these concepts and passive devices of traditional domestic units were developed as a solution to socio-cultural, economic and environmental parameters. In the past and before the invention of electrical energy, housing units were designed and built in the MENA region; mainly based on the use of passive vernacular architecture. In Qatar for example, wind-catchers, courtyards, small openings, lengthy vertical lattices, thick mud-baked bricks walls, have been adopted in vernacular domestic units and housing patterns (Al-Hinai, Batty & Probert, 1993).

Opting for other design strategies other that the design guidelines and devices of the domestic traditional housing units flourished in those regions since the oil boom of the 1970s, with great influences from the Western modern architecture. New modern architecture forms such as detached houses are designed and built using wide glazed facades and other active devices. These new design strategies are largely used nowadays in the MENA region. While showing modernity and technological advances, these structures consume high amount of energy and endanger natural environment. The switch in design strategies happened despite the negative impact caused by these "foreign" strategies on uses and habits of local indigenous populations. This caused dramatic increase in energy and water demands. Such houses and design strategies combined with high-income owners/developers and reduced electricity and water fees lead to astronomic energy and water consumption figures coupled with high negative impact on the natural and built environment.

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Figure 01: The vibrant vernacular Suq Waqif in Doha (Fadli, 2019).

The development of Smart Sustainable cities through the use and applications of disruptive technologies developed further with the advent of the 4ᵗʰ Industrial Revolution. Building Information Modeling (BIM), Virtual Reality (VR), Machine Learning (ML) and Artificial Intelligence (AI) and other means of 21ˢᵗ Century technology disrupted and provided a high-speed fast-forward move for the way we design our buildings and cities. Computational methods and generative parametric design allow better understanding and optimized applications of parallel interactions integrating several factors to achieve better results. The flexibility of computer programs, plugins and apps also makes it possible to integrate a wide variety of stakeholders in planning and design processes simultaneously and diachronically, thereby respond to people's needs and aspirations through real-time collaboration.

In this perspective, the "Smart Home" concept has been developing over the past few decades. It has been introduced in few different terms such as "Domotica"1 (Domotics) (Berlo & Vermijs, 1993); (Berlo, 1994); (Recuero, 1999), "Smart Home" (Lutolf, 1992), "Internet of Things" (IoT), and "Smart Living" (Fadli et al, 2015). Of course, there are numerous features towards having a "Smart Home" including but not limited to indoor air quality, energy efficiency, lighting, security, safety, comfort, entertainment, and accessibility. Moreover, software and hardware are widely diverse when it comes to each of these features. It is noteworthy to mention that apart from architecture and related design themes, several other disciplines such as automation, networking and optimization, mobile computing, Internet of Things (IoT) are integrated (Solaimani, Keijzer-Broers, & Bouwman, 2015). The pioneering launch of "Smart Home" concept dates back to early 1980s, when the American Association of House Builder introduced this new term for the very first time (Chan, Esteve, Escriba, & Campo, 2008). "Smart Home" is interpreted differently by different sectors and disciplines. As such, in healthcare, "Smart Home" is a preventive care place where occupants' or patients' health is monitored and assistance is provided for those in need (Demiris, et al., 2004). In another domain, construction, "Smart Home" is a place where residents could enjoy the technology and features installed can be controlled automatically in buildings (Hu, Wei, & Cong, 2013).

Figure 02: Typical Khaleeji home, located in Doha, Qatar is used for experimental study. Image courtesy of MZ & Partners (2017).

Over the last ten years, a sensitive raise happened in using, adopting sustainable design, related concepts, and principles (Fadli, 2014), (Bahrami et al., 2016). Several world leading institutions like the U.S. Green Building Council (USGBC) and the UK based Building Research Establishment Environmental Assessment Method (BREEAM) incited several countries, regions and governments to develop their own labelling and assessment systems (Attia, 2014), (Fadli, 2014). Energy (E) indicator is considered with Water (W), as one of the most important if not the most important indicator of these models and matrices. Many systems were developed and launched in the region such as Estidama Pearl system (UAE, 2009) and GSAS (initially QSAS) (Qatar 2010). The majority of these guidelines and models are performance based rather than focusing on the type of buildings and most importantly on the relationship between users and the spaces, and on how to innovate by developing integrated smart systems for sustainability. The lack of residential-specific green design guidelines proved that new research is highly timely and of high necessity and priority in Qatar and the region due to the harshness of the climate but also for social, economic and environmental reasons.

The passively designed entity targets to reach a minimum of half reduction of cooling load on a yearly basis as well as lowering down the electrical energy and water usage. The proposed house also aims to reduce investment costs by the fifth (Amato & Skelhorn, 2015). To-date, scarce and rare are those perceptive evidenced outcomes that have been mentioned and published (Fadli, 2016).

A smart home occupant can monitor and control the interface to feel the intelligent surrounding like 3D computer games. To the contrary agent-based monitoring (no occupant-machine inter-action), info insertion by occupants in a virtual place is gathered. Furthermore, Virtual Reality could be utilized to enhance the users' experience and let the user observes and feels for him/herself. This is considered as a user-oriented approach. V-PlaceSims presents a better understanding to users, which helps architects to find out about users' desires more clearly (Lertlakkhanakul, Choi, & Kim, 2008).

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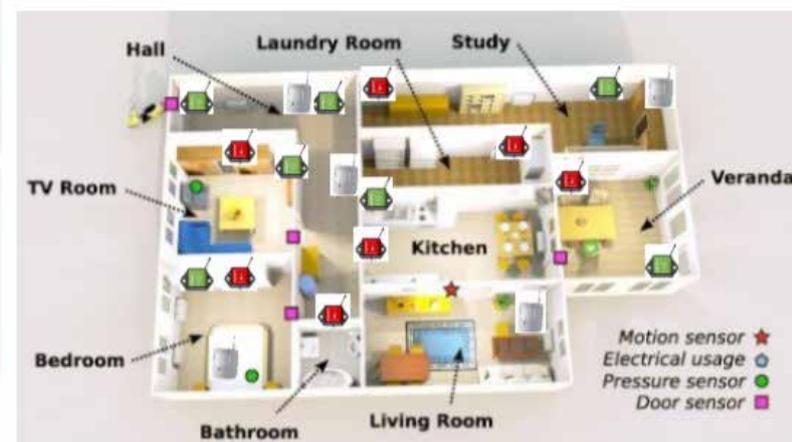
Figure 03: Sensors installation layout and configuration (Fadli et al., 2017).

This opinion essay targets and explores the major dimensions of sustainability based on its three-legged-impact model of socio-cultural (inc. health), economic and environmental aspects. On the socio-cultural dimension, it provides great insight in the way common users will be able to interact in a smart way with their homes, buildings, spaces, neighborhoods and cities at large. Moreover, they will constitute one single entity with complementary status. Home-Human correlation will work in both ways rather than human-home in one side. This will produce a chain of positive impact on the health, social-cultural and environmental aspects of the vernacular "bayt" transformed into smart sustainable homes in particular and interactive buildings in general. As per the health of users and the environment, the smart home app will provide ways of intelligent monitoring of indoor environment, which would positively influence users' health, comfort and wellbeing (AlFadala and Fadli, 2019). While economic patterns will be enhanced and a more efficient strategy adopted when it comes to energy and water consumption and recycling, hence proving economic and environmental positive effects to protect and safeguard both the natural and built environment (Fadli et al, 2014). The smart sustainable concept adopted into buildings, neighborhoods and cities will deliver the-state-of- the- art modern smart homes imbedded within the socio-cultural roots of the medina and its communities and society but also improving the health of its occupants and users as well as the economic and environmental patterns of the related natural and built environment.

The principles of smart sustainable design are being developed from research-lead design, where the knowledge is transmitted to students through the "students-centered pedagogical approach" and the interactive studio to definitely move towards practice through consultancy and Research, Development and Innovation.

From indigenous vernacular 'ingeniosity' to smart and sustainable, only the Medina and its buildings can make it through two millennia…and beyond!

Al Thumama Stadium: Local and Global Architectural Reach

Hani Awni Hawamdeh

Arab Engineering Bureau: AEB, Doha, Qatar

hani@aeb-qatar.com

The world cup stadia have been a constant concern for the hosting countries. Many of them have become a burden on the economies of their countries, only to become white elephants after the tournaments end. Therefore, the core mission of the Supreme Committee for Delivery & Legacy in Qatar was to ensure that the World Cup Stadiums are built with a legacy and to remain functional in the long run, not just as facilities, but as cultural icons. Such efforts have promoted the exercise of stadia building in Qatar as a positive and unique experience. As a firm, we, at Arab Engineering Bureau, are honored to be part of the effort all through the making of Al Thumama Stadium, which will be discussed in this paper. Instead of a white elephant, Al Thumama Stadium is arguably a symbol of the local identity that will become part of the World Cup legacy, whilst being a state-of-the-art facility that plays a vital role in development of its surrounding neighborhood.

Arab Engineering Bureau (AEB)

Established in 1966, AEB was the first firm of its kind to be established in the State of Qatar; it was acquired by Ibrahim M. Jaidah in 1991. Under Ibrahim's leadership, AEB - which he initially acquired with only 6 employees, has evolved to be an enterprise with over 600 employees across 4 international offices and has completed over 1600 projects.

Ibrahim Jaidah's commitment to cultural awareness and growth, and his passion for research resulted in the publication of books titled as *History of Qatari Architecture*, *99 Domes* and *Qatari Style* that have been widely used as reference materials in the academia.

Supreme Committee Requirements and the Concept Design

Through a tender competition, the firm was challenged to reinterpret the Gahfiya shape into the design of a stadium. The Gahfiya, a part of the traditional headdress in Qatar and the region, is considered a rite of passage from childhood to adulthood. Young men wear it for protection from the sun, before they start adhering to the entire headgear worn by grown men. Therefore, Ibrahim M. Jaidah chose to keep the literal shape of the traditional hat, as protection against the sun is one of the hat's functions.

The Team

To meet the FIFA and the Supreme Committee requirements, a group of strong cross-disciplinary experts was actively integrated into AEB core team. AEB, as the Lead Design Consultant and Principle Architect, appointed Fenwick Iribarren Architects for the Sports Architecture, Hilson Moran for MEP and Schlaich Bergermann Partner for the Structural Engineering. Qatar University, the national university, performed the wind tunnel testing and a detailed review and verification of Computational Fluid Dynamics (CFD) that simulated the Bowl and Field of Play cooling system performance. The Principal Architect and the design management core team closely worked to manage the larger design team members to actualize the design and reach the goals set for this stadium by the Supreme Committee, in addition to complying with FIFA's Compliance Program, and local codes and regulations. Accordingly, a variety of software were also used including BIM which played a strong role in modeling the design.

Location

The Al Thumama Stadium is located south of central Doha and is well positioned between the Al Wakrah and Aspire Precincts. It lies at the Eastern end of Al Thumama Street, close to the neighborhood

of Al Thumama, soon to be surrounded by important new highway developments and residential zones. Surrounded by a variety of different uses, the design responds to each one of them and creates a balanced and ordered site master plan. Therefore, the masterplan focused on responding to the needs of the neighborhood and connectivity with its surroundings, while playing the role of a buffer between the neighboring residential and industrial areas and having social integrity by reflecting the local culture.

Stadium Facade and Roof

The facade aimed to embody the true essence of the Gahfiya being light in weight and white in color. By using different aperture sizes and strategic positioning of the cladding material, a traditional woven pattern was achieved.

The roof is created to maximize the sun light penetration while considering the comfort of the spectators in the stands and the cooling strategy.
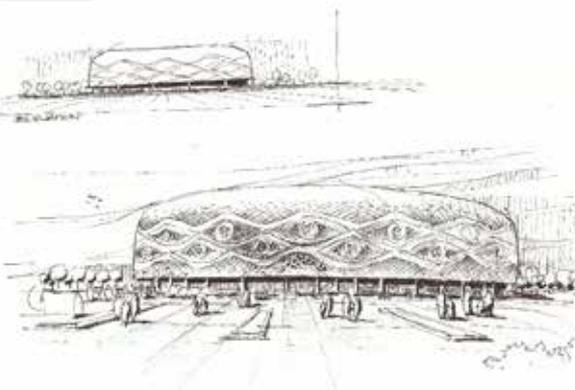
Urban Integration

In all the stadia built for the World Cup, Supreme Committee required strict adherence to the three modes plan, which is Base Build, Tournament Mode and Legacy Mode. The Base Build Mode is to construct the stadium and the essential precinct facilities needed to receive the testing events before the tournament. The Tournament Mode is how the design of the stadium and the site will accommodate the spectators for the World Cup, while the Legacy Mode is how the design will be transformed after the World Cup to remain a vital component of its surroundings. Therefore, the site is designed to integrate and respond to, complement and enhance the surrounding area, instead of only occupying the space. The stadium is located at northern part of the plot along an uncovered parking area dedicated to VIP, Hospitality, Media and FIFA/LOC in the Tournament Mode. In addition, the existing venues at the center of the plot include the training fields and the Showcase Stadium. Traffic impact assessment was carried out to cover a wider area of the city, as to ensure proposing the required mitigations to maintain the smoothness of traffic flow. Finally, the Legacy Mode includes disassembling the upper tier and adding new components including two clinics, a boutique hotel and two clubs' headquarters.

Design Language

Integrity of design language was sustained through the rhomboid shape, which can be seen in the facade, dissemination across the design. The diamond is a very popular figure, has movement and is more commanding and distinguishing than the square or circle. It is also an important element in

Arabic calligraphy, as it resembles the trace of the calligraphy pens used for most of the prominent styles. Such a phenomenon has allowed the design language to become even more deeply rooted in the local culture.

Building on the established architectural language, the design team created a seamless transition in space between the outside and the inside through the patents on the internal walls and the iconic Gahfiya wall in which different kinds of local hats are displayed. The external facade experience is also taken inside in both hospitality designated areas and the bowl of the stadium adding richness to the visitors' experience through light and shadow and reflection of the past.
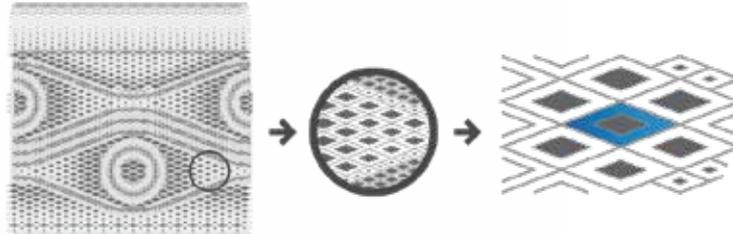
Al Thumama Stadium is a placemaking project, with a unique look, aimed to become more than a building. It was designed to become part of the FIFA World Cup 2020 legacy and to continue on connecting the neighborhood and attracting families and individuals into a culture of sports. It is a design that reflects the past and opens doors to the future.

Heat and Air Quality

Due to the high temperatures in summer in Qatar, much attention was given to overcoming the heat challenge. Sun path analysis were done to determine the shape and size of the oculus on the roof, allowing for a sufficient amount of light without disturbing the viewers. Simulation was done to assess the CO_2 concentration within the bowl to determine the fresh air flow requirements. Wind pressure analysis was completed in collaboration with Qatar University to ensure the building structure stability and the effect of the wind on the indoor air temperature and quality. CFD analysis was done to estimate the cooling load and to decide on the right airflows and distribution to ensure maintaining the targeted temperatures on bleachers and playground. All types of tiered seating will be provided with cool air, delivered via a displacement principle below the seating to maintain the required environmental conditions. The methodology of supplying the cooling air will vary with the type of seating and the location within the stadium, to reflect the solar load imposed in different parts of the stadium.

Cybernetics

To ensure the comfort and safety of the spectators cybernetics systems were devised in the entire site, including BMS, ESCADA system, data & telecommunication, security systems, CCTV, access control, BAG & MAG screening, fire alarms, broadcasting, lighting controls, and central clock system.

Sustainability Strategy

The project design targets a GSAS 4 Star rating for GSAS Design and Build (GSAS Sports v2.1) and under GSAS Construction Management v2.1 - Issue 3.0 with a focus on: energy and water efficiency in addition to material and resource management. The design combines passive design strategies with advanced building systems to deliver a sustainable and iconic building that provides a safe and comfortable experience for its occupants including the indoor environment inside the Stadium and the outdoor experience within the site and Precinct. The project has so far achieved exemplary performance standards in the use of recycled materials, sustainable sourcing of products, building

energy performance and reduction of water use. It is on track to optimize its energy performance to achieve an improvement of 30-35% above international benchmarks including ASHRAE 90.1.

Where Are We Now?

Kas Oosterhuis

Researcher-Qatar University, Emeritus Professor TU Delft
Director ONL

oosterhuis@oosterhuis.nl

After 16 years of leading the Hyperbody research group as professor of practice at the TU Delft, I wanted to do something completely different and looked at the Gulf region for further educational and professional activities. I was familiar with the region, having lectured in several countries of the Middle East and eventually having realized an office building in Abu Dhabi. My practice ONL [Oosterhuis_Lénárd], which I run together with my wife and business partner visual artist Ilona Lénárd, proposed a number of iconic architectural proposals for hotels and office towers, and was eventually awarded some prestigious commissions for master planning projects: the redevelopment of Manhal Palace, the residence of previous ruler Sheik Zayed in Abu Dhabi. Our continuous efforts to contribute to the building market in the UAE culminated in our realized design for Mr Abdullah Al Nasser, the LIWA tower in Abu Dhabi [2014]. I Joined the Department of Architecture and Urban Planning [DAUP] at Qatar University in September 2017.

Featured Realized Projects

My future has always coalesced with the here and now. Many consider my projects to be futuristic, but for me they are the ultimate daily reality, taking advantage of the technological and social achievements of the day, as reflected in my featured projects the Saltwater pavilion [Neeltje Jans, 1997], Web of North-Holland [Haarlemmermeer, 2002], A2 Cockpit [Utrecht, 2005], the Bálna Budapest [Budapest, 2013], and the Liwa Tower [Abu Dhabi, 2014]. These internationally widely published projects are typically based on the paradigm shift in design practice from 3d modelling to parametric design and the other paradigm shift from mass production of series of the same to mass customization of series of unique building components. An important source of inspiration are complex adaptive systems like swarms of starlings, fascinated as we are by the ever changing configurations of the swarm. We have successfully implemented the principles of the swarm to the way building components are flocking together in the dynamic complex adaptive design systems and the direct file to factory link from the parametric design scripts to robotic CNC controlled production [Figure 1].

Design Methods ARCT 320 Fall 2017

The first project visual artist Ilona Lénárd and I did was the Design Methods and Theories course. One of the things we asked the students is to make a painting that expresses their emotions, without any reference to nature or existing products. No portraits, no trees, no animals, no houses, cars, no coffee cups. We taught them to express abstract ideas that were waiting to be set free. We believe that abstract design thinking is essential to become an architect or artist, since you will need to construct a new reality, which has not been there before. We asked them to put their individual paintings together to form a larger painting, thus stimulating teamwork and creating shared values [Figure 2].

ICE Café Interactive Public Art

In the meantime, in fall 2017 I wrote several research proposals, internal grants for a smaller research project, and through QNRF for NPRP grant. Three proposals were rewarded, the GSM4Q conference, the QU MANIC research for Multimodal Accommodation for the Nomadic International Citizen and the NPRP Qatar Robotic Printing project. We developed together with a team around the Head of Department Dr Fodil Fadli, a concept for an Interactive towering structure, to be located in front of the entrance of the College of Engineering B09 Building, functioning as a coffee shop and an iconic public art structure to represent

GSM4Q
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connecting people spaces machines

Proceedings of the International Conference on the 4th Game Set and Match (GSM4Q-2019)

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the dynamic nature of the College. The Interactive ICE Café tower would swing and rotate in its entirety to have a life of its own. The 16m high tower would bend itself in the direction of prevailing winds as to catch a breeze and bring down the breeze all the way down the coffee shop on ground level [Figure 3].

Maidan Monument

Together with a team of Qatar based artists and QU architect-researchers, we joined an international competition for a public art project in Kiev. The brief was to design a monument for the Hundred Heavenly Heroes, those who gave their life in the 2015 revolution. The images of the Maidan Revolution of 2014-2015 have made a deep impression in the world, the photos of the dramatic sceneries, especially the night views went all over the world. Our design team has chosen to take the flag as the virtual carrier of the geometry of the Maidan monument. An imaginary volume of a waving flag is populated with exactly hundreds points/nodes, each of them representing one of the hundred heroes. The nodes form a spatial three-dimensional network, therewith representing the mutual connectivity and the robust collaboration between the heroic people, whether they belong to the heavenly hundred or to the thousands of their fellow protesters [Figure 4].

Machining Emotion Robotic Workshop

One of the most rewarding experiences during our stay in Doha was the conceptualization and execution of the robotic workshop. Together with Ilona we had previous experience with a robotic painting project titled Machining Emotion, using a large robot arm to produce a workflow merging intuitive painting with scripting algorithms and robotic execution of the paintings. We teamed up together with Dr John John Cabibihan from MIE (Mechanical and Industrial Engineering) Department at College of Engineering to offer a robotic workshop at Doha Fire Station, open for students of Qatar University and artists in residence of Fire Station. There was one smaller humanoid robot, another very slow pick and place robot, we had a few simple drones, and we bought some vacuum cleaning robots to play with. We realized two large ground-based paintings, one additive painting, adding acrylic paint to a large canvas of 2 x 10m, and one subtractive painting of the same dimensions. For this one, we flooded the working area with flour that was to be sucked up by the cleaning bots [Figure 5].

Multimodal Accommodations for the New International Citizen [MANIC]

The MANIC research builds upon earlier studies by the Dutch architect John Habraken on open building architecture providing for flexibility in use of the homes [N.J. Habraken, Supports: Alternatives for Mass Housing, 1972], and on the visionary art project New Babylon by the Dutch Artist Constant Nieuwenhuys [catalogue New Babylon, Haags Gemeentemuseum, 1974] In New York, in 1980's, the concept of the loft' became popular. The MANIC research takes the loft concept and New Babylon to a new level, by introducing programmable interior furniture and fit-out as to transform in real time the available space into different types of usage, as spacious as possible, programming the 50m2 unit to become a bathroom, a bedroom, a living room, kitchen or as an empty space of 50 m2 for yoga sessions. Multimodal Accommodations facilitate the Nomadic International Citizen [MANIC]. Each individual spatial unit may be booked for a different function and for any period of time. The ubiquitous booking system facilitates the nomadic 21st century international citizen [Figure 6]

West Bay North Beach Master Plan

I taught at the Architectural Association in the years 1988 - 1989. In my unit I had one student from Qatar. After 30+ years I met Badria Kafood again in the DECC where she had a stand with her own architectural office. I asked her to team up with us to submit a design for the West Bay North Beach competition published by Ashghal. Our concept for West Bay North Beach [WBNB] master plan aims at interweaving the generic with the iconic. The generic buildings are meant to be able to design and build within a very short period of time as to be ready by 2022. The iconic buildings on the triangular islands are meant to form the attractors

to comply with Qatar Vision 2030 and will be developed between 2022 and 2030. The Generic Towers; the triangular treasure island containing the leisure parks and the landmark buildings are connected by a smooth network of elevated traverses, providing shade and comfort for the pedestrian. The traverses connect the Generic Towers to each other and the existing area of West Bay North Beach to the new developments extending into the bay of Doha. Inserted between the existing towers at West Bay North Beach area, the master plan foresees the realization of a few striking urban farming Food Towers, providing for food to be produced and consumed locally in West Bay [Figure 7].

Little Babylon Interactive Sculpture

Rezone of the Netherlands has been the client for the inflatable Mothership sculpture called Little Babylon, which I designed in a team with the Air Design Studio, and the app developers Marijn Moerbeek and Thomas Rutgers for the interaction. We installed Little Babylon at Doha Fire Station and later at Qatar University Library during GSM4Q conference. Mothership Little Babylon communicates this data with the audience in an interactive way as a dynamic, audio-visual performance. It adds a digital, emotional and social layer to a current urban condition. The pavilion personifies the digital city and mines twitter for specific topics and translates this data in movement, visuals and sound, which together show the sentiment and temperament of the specific city [Figure 8].

Public Art | ARCT 120

In fall 2018, I taught the ARCT 120 Introduction to Architecture and Allied Arts to first year students. The first brief was to choose a household object [coffee machine, vacuum cleaner, mobile phone holder] and dissect it into its parts. Then I asked them to draw these parts as if they were the designer. I asked them to show how the parts work together to form the working device. Later, I requested them to describe how the parts were made, what materials were used and how these were produced. The next task I gave them was to analyze parts of a car and the context they were in. I asked to focus on headlights, look at them from all angles, model them and draw them. In this way they learned how a complex project like a building actually is a composition of different parts that are designed to fit exactly together to form the house. Finally, I asked them to design a substantially large piece of public art and make a 1:10 scale model on a 60 x 60cm ground plate [Figure 9].

Figure 1: | Bálna Budapest | design ONL / Kas Oosterhuis | Budapest 2014.

Figure 02: | ARCT 320: Design Methods and Theories course | tutors Kas Oosterhuis and support artist (Ilona Lénárd) | QU DAUP Fall 2017.

**Figure 03:** | ICE Café interactive Tower | initial sketch by Kas Oosterhuis | 2017.
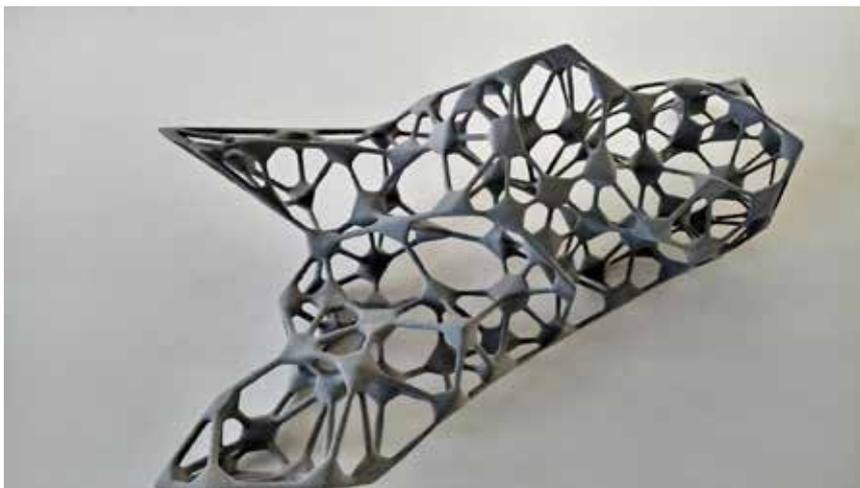
Figure 04 | Maidan Monument | Kiev | design team Kas Oosterhuis, Ilona Lénárd, Yassmin Alkhasawneh, Najeeba Kutty,Diogo Esteves | 2018.

Figure 05: | Machining Emotion robotic workshop | overview additive and subtractive painting | Doha Fire Station Workshop 4 | 2018.

Figure 06: | Multimodal Accommodations for the New International Citizen [MANIC] | researcher Kas Oosterhuis 2018.

Figure 07: | West Bay North Beach | master plan by Kas Oosterhuis / Doha architect Badria Kafood | 2018.

Figure 08: | Mothership Little Babylon | design ONL / Kas Oosterhuis | Doha Fire Station 2018.

Figure 09: | ARCT 120 Introduction to Architecture and Allied Art public art project 1:10 scale model by first year student | Fall 2018.

Towards an Artificial Architecture: *About Superintelligent Space*

Philip Morel

EZCT Architecture & Design Research, 32 rue Saint-Antoine,75004 Paris

ezct.philippe.morel@gmail.com

'Just as there are odors that dogs can smell and we cannot, as well as sounds that dogs can hear and we cannot, so too there are wavelengths of light we cannot see and flavors we cannot taste. Why then, given our brains wired the way they are, does the remark, "Perhaps there are thoughts we cannot think," surprise you? Evolution, so far, may possibly have blocked us from being able to think in some directions; there could be unthinkable thoughts.' (Hamming, 1980).

'We have preconceptions about how an intelligent robot should look and act, and these can blind us to what is already happening around us. To demand that artificial intelligence be humanlike is the same flawed logic as demanding that artificial flying be birdlike, with flapping wings. Robots will think different. To see how far artificial intelligence has penetrated our lives, we need to shed the idea that they will be humanlike.' (Kelly, 2012).

In the essay *The Doctors of Tomorrow Will Be Supercomputers*, published online at futurism.com, Leary (2017) says doctors will be replaced by artificial intelligence-fed supercomputers. This is in line with many theorists and futurists including Kelly (2012) who, on a more "material" level, declared in Wired: *'Even those areas of medicine not defined by paperwork, such as surgery, are becoming increasingly robotic. The rote tasks of any information-intensive job can be automated. It doesn't matter if you are a doctor, lawyer, architect, reporter, or even programmer: The robot takeover will be epic. And it has already begun.'[Kelly,2013]* For this last author, with whom I can only agree, if we are now at a *'point of inflection'* in the use of robots, it is because they have become intelligent machines. Indeed, *intelligence* is the whole question...

Architecture has, just as science or comics, its own history of superlatives. Thanks to the eponymous exhibition of Pistoia, in 1966 a 'Superarchitecture' (Superarchitettura) was added to the supercomputers and superheroes, which according to its theorists was an *'architecture of superproduction, superconsumption, superincitation to consume, supermarket, superman and super gasoline'[Superarchitettura, 1966]*. As everyone knows, this superarchitecture has become, following Superstudio and Archizoom, a paradigm common to many other avant-garde groups which, according to a vanguard definition as *'dictatorship of reality'*, have naturally developed an "architecture of reality". In fact, superarchitecture had incorporated the essential elements of the reality of an era, if not a computational environment just nascent or embryonic whose signs appeared in the abstraction of grids and series, usually produced by hand on typewriters, or in the coldness of otherwise narrative images. Computation appeared here and there but without the calculation being truly effective and in action; everything was as if it still belonged to reverie. There are some reasons for that. Firstly, the European industrial context of the time as well as the hyper-politicization of the social sphere obviously played against an in-depth analysis of computation as well as the various but inevitable consequences of the quantitative and qualitative evolution of computers. Among the architects and researchers who were most interested in this issue, very few had the opportunity for direct access to the machines themselves, which were expensive, cumbersome, and therefore extremely limited in Europe. Secondly, the visceral rejection of modernism contributed to a global discredit on a whole section of research inspired by science. "Proto-computational" architects and artists were often wrongly labeled as scientistic or naively progressive late modernist people, at the very moment when the concept of scientific progress was losing its authority. Like Leonardo Mosso in Italy, Seguí and

Buenaventura (1968, 1974), active at the Computing Center of the University of Madrid (CCUM) – an experimental space developed and financed by IBM from 1968 –, Jozef Jankovič in Czechoslovakia or Konstantinos Doxiadis in Athens, many researchers working around the possibilities provided by computers appeared either as positivists, or as anti-Marxists, or both.

Finally, confronted with a formalism that rarely succeeded in renewing in depth the codes of modernism and with the voluntary or forced departure to the United States or South America of many emblematic figures of the European avant-gardes prior to 1939, it was more judicious to turn to truly new experiments like those of Pop Art or Conceptual Art than attempting to revive an outdated modernist art that became bourgeois and perfectly boring. Thanks to history of art and, to a lesser extent, to the history of architecture of the 1960s and 1970s, we know that the United States has been both more active and more receptive to experiments conducted with computers, whether on (programming) languages themselves or by making an instrumental use of these languages for the development of new forms and new spatial logics. The positive influence of great formalists of European origin such as Albers or Moholy-Nagy, many of whom had prestigious academic positions, the open minded attitude of the most original American creators (R. Buckminster Fuller, J. Cage, etc.), the relative absence of a monolithic stylistic school prior to the Second World War against which it would have been necessary to take an equally monolithic opposite stance, as well as the political and economic incentives for a new science and a new aesthetic have unambiguously allowed the emergence of research in the United States for which a context of refusal of ongoing scientific policies, then associated with liberalism and imperialism, did not seem the most favorable. In any case, and perhaps because in the 20th century the question of knowledge was mainly addressed by positivist philosophers (including Viennese neo-positivists). Superarchitecture has never been theorized in relation to *knowledge* itself: neither as architecture of intelligence nor as architecture of superintelligence. Now, in the age of supercomputers and strong artificial intelligence, it is useful to define the latter, at least in its broad outlines.

To theorize the architecture of superintelligence or at least *superintelligent space* would require in all rigor to describe in advance the concept of superintelligence with its variants. We will assume here that the reader is already informed on this question and if it is not the case we invite him to have a look at the most influential books and papers (Bostrom, 2014). Nevertheless, as a very general reminder and before addressing the question of architecture, let us consider superintelligence as a radical increase in the general intelligence available, intelligence of machinic or human origin. If the hypothesis of the Singularity, as propounded by Kurzweil (2005), which we recall, is an empirical hypothesis based on historical facts, and is based on the exponential increase of machine intelligence, there is nothing in theory against the possibility of a parallel increase in biological intelligence, for example through genetic engineering. In fact, it is quite probable that the intelligence of the future will be integral and that it will not recognize the usual natural vs artificial and physical vs biological distinctions; the possibility of synthesizing DNA already demonstrates this. We are thus moving towards a distributed intelligence magma ("The" cloud…) which is to become the main component of any future architecture. An architecture massively generated by computational procedures – bringing together computation and data –, which will manifest itself through "superintelligent space". That this last one evokes various criteria, parameters and concepts associated with artificial intelligence - what exact type of machine learning, optimization of algorithm etc. - is not essential, moreover its artificiality is not as in the case of current AI a purely technical artificiality. Superintelligence is not the collective intelligence of neo-operatives and classical humanists, but not being human does not mean it is simply mechanical. It is in fact *artificial*, in every sense of that word. It refers to the general hybrid intelligence in circulation, human and artificial, whose effectiveness comes from the very possibility of making symbolical and numerical computation through a prior formalization, so thanks to its "artificialization". As a result of this general formalization and translation that flatten out the different forms of intelligence, it is an "artificial general intelligence" (AGI) that would have

succeeded in integrating all the existing knowledge, giving birth to a concept of intelligence with both theoretical and practical efficiency, this further reinforcing the criterion of Turing universality while removing the anthropomorphism or biomimicry of the famous 'Turing test'.

Indeed, the objectives of this test first defined to "demonstrate" the possibility of an artificial intelligence at least equivalent to human intelligence, or more modestly to address criteria of intelligence, have been diverted to reintroduce a perfectly outdated anthropomorphism. In the field of architecture this anthropomorphism, indefensible and especially unusable, has been and is still regularly replaced by a biomimicry whose main asset, of a socio-political nature, is that it makes the *extra*-ordinary performance of computers and software ordinary and acceptable to the greatest number, including architects. It's not the least of the contradictions - I call it *The Social Paradox of Artificial Intelligence* - to see so many people, including those who need it, speak out against artificial intelligence and by extension against the general artificial intelligence, in favor of a respectable natural intelligence; natural but rather badly shared... Beyond the fact that the affirmation 'everything is in nature' makes us individuals of the Renaissance - so somewhat old ... - it does not say anything about the level of "naturalness" we are speaking about.

To say along with David Deutsch that all forms of intelligences, *in vivo*, *in silico*, etc., obey the same laws of physics (including those of quantum physics) and can therefore be reduced to an artificial general intelligence (AGI) whose real understanding still eludes us, is obviously not the same as finding that humans are experts in logic or chess and that ants are experts in swarm intelligence... all the more so when humans are surpassed at chess. The neo-romantic sanctification of nature as it manifests itself in the most obvious way also does not provide a solid argument for our inclination to regard ourselves as the alpha and omega of "Creation" and intelligence, and this only because so far we are the only species that made use of a rationalistic thought - in the service of a rational attitude and quite often also at the service of mass destruction. As K. Kelly[2012] reports it, *'we have preconceptions about how an intelligent robot should look and act, and these can blind us to what is already happening around us.'* It was also as early as 1980, certainly concerning a different problem of epistemology, what was recalled by R. Hamming summoning our own sensory limitations, which should preserve us forever from any presumptuous attitude with regards to intelligence in general. In fact, neither with the most radical avant-gardes of the beginning of the 20th century nor later with Peter Eisenman whose architecture is entirely directed to such an overtaking, did we really go beyond naturalism and mimesis. This for the simple reason that so far, we have never had to deal with an intelligence that, to take up the reactions to AlphaGo's victory against Lee Se-Dol from 9 to 15 March 2016, is external to us and manifests itself to us as an Alien. So far, the history of machines has merely been a story of artefacts understood as quantitative extensions of our intelligence, if not more simply mere extensions of our bodies. What a rocket engine and a microscope - including electronics - have in common is that they both incorporate our knowledge - our theories - for our own quantitative extension.

In one case we send our bodies, our tools, our theories or all together in orbit, in the other we project our concepts at the heart of matter to confront them with what we suppose to be ever finer degrees of realities. The constant evolution and refinement of our theories obviously gives the impression of profound qualitative changes, but this is to be put into perspective. In fact, our logical presuppositions vary little or do not change, as evidenced by the fact that it is almost impossible for us to spontaneously consider laws and behaviors that do not appeal to classical dualism (the law of the excluded middle in logic).

Our existence ultimately rests on an extremely limited set of rules forged from our daily experience so that we are able, as for example mathematicians and physicists do, to free ourselves from them only at the expense of difficult and tedious efforts of abstraction, efforts that on a social level are clearly reserved for a minority of the population (although a greater number of people are capable of it) and for which we must really evacuate our direct intuition to the benefit of a *superior form of intuition* in which we do not really understand much.

If we observe the evolution of logic one finds how authentically qualitative changes are rare, as it took more than two millennia between Aristotle and G. Frege or between Aristotle and G. Boole for the logic to become truly modern. This logic as a product of *human* intelligence remains so deeply attached to that specific form of intelligence that it has developed only thanks to mathematicians whose intelligence appears precisely different, even *super*-natural, like a *superintelligence*. The current degree of abstraction of logic and, more generally, of mathematics and mathematical physics can no longer show advances in these disciplines as anything other than the productions of Alien individuals having succeeded in making a concept of intuition which completely escapes most individuals a material reality: in fact a cerebral faculty. Things happen not only as if the superintelligence escaped explanations - this is the case for some forms of strong artificial intelligence - but more radically still as if the phenomenology of superintelligence escaped all mental synthesis, in fact as it escaped phenomenology itself. We indeed perceive the effects of a new intelligence, but we do not grasp the rules, like young children in front of most phenomena or like adults who moved within a physical environment for tens of thousands of years without ever being able to faithfully reproduce most of its elements, at least before the invention of perspective. It is not uncommon to mention the Renaissance and the inventions of perspective and printing in the context of analysis of the current computational revolution, in general to bring the consequences of these 15th century inventions closer to the consequences of the invention of the computer. Nevertheless, if the inventions of perspective and printing have obviously marked the beginning of a new era, they may have even more embodied the end of a succession of previous eras and wanderings. Indeed, the perspective, prelude to a new vision of the world, was also the ordering - almost the final point - of a set of bodily-experienced perceptions never translated into spatial thought through scientifically articulated concepts for which both an absence of representations and rigorous geometric constructions were crippling.

There could be no real theory of space - everyone will understand that I consider geometric triangulation not as a theory of space but simply as a measurement - anterior to the invention of perspective for the simple reason that the foundations of an authentic understanding of space was lacking. How, in all rigor, theorize what one cannot even represent correctly? To better perceive what the absence of a general theory of space represented, it is enough to remember that for each region, country and tradition could be attached a specific representation stretching distances and planes, and deforming volumes and objects. With hindsight, we wonder by what miracle a seemingly unachievable peak of geometric intelligence appeared after long millennia is now within the reach of every child at the end of primary school. The task was authentically intractable, and the miracle consisted of a gradual evolution of our scientific methodology. If I come back to computation, although each interval of time of adaptation and time of adoption is always shorter, computation is socially comparable not to the invention of perspective as a "solution" - as the end of an era marked by the ordering of our perceptions - but largely to the appearance of what preceded, the Neolithic Period. Computation marks the entry into a new (post)history - *'the story of synthetic nature and Mendelized Campaign*– entirely geared towards a process of 'cerebralization' for which the tools of construction and action on the world are given to us; just as they had been given to the greatest number by a few individuals or creative peoples, and obviously by parents to children, the tools allowing tillage, breeding, the crossing of rivers or the manufacture of boats. All that makes it possible to realize the dream of logical positivism – a logical (re)construction of the world and even more radically its logical emulation, i.e. its *simulation* – is now here, under our eyes and available. Nothing prevents us from making use of it, no more to travel in the physical and information space than to develop a new architecture.

If, as mentioned above, the space of superintelligence or *superintelligent space* is massively generated by computational procedures, many will tend to consider from the angle of causality that we understand this space and that we have circumscribed it. Nevertheless, contrary to classical and modern rationalist projects - the global Rationalist Project - whose origin can easily be found, the

computationalist project of a superintelligent space is based on the strict impossibility of going back to the beginning of computational procedures for which most of the operations escape us (technically and theoretically speaking *we will be able to run backward most of our computation*, but again I do not consider here computation on a uniquely technical level). Behind each petabyte of data are hidden other petabytes, behind each algorithm, approximation and rounding operation are hidden thousands, millions or billions of other algorithms, approximations and rounding operations. Behind each step of a computation within a sequence certainly finite but that gigantic dimensions make infinite with regards to any human faculty, hide trillions of trillions of discrete states that act as trillions of trillions of partial causes. If, mathematically speaking, beginnings and ends do exist in finite-state machines, these concepts are among many other certainties no longer of any practical use, since they completely escape all perceptual capacities and all phenomenology, the latter being a transitional and now achieved stage in the history of theories of perception. Finally, one will now have to accept *'leaving things without explanations'*. It might, perhaps, be *'characteristic of a superior culture'[freiedrich,1996]*.

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'La Superarchitettura è l'architettura della superproduzione, del superconsumo, della superinduzione al superconsumo, del supermarket, del superman e della benzina super.' As stated by the "Superarchitettura" exhibition (at *Jolly 2 Gallery* in Pistoia, Italy) manifesto presented at the opening, on December 4th, 1966.

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Digital Master Builders: Disruptive Construction Technologies

Philippe Block

Block Research Group, Institute of Technology in Architecture, ETH Zurich

block@arch.ethz.ch

1. Introduction

The United Nations Department of Economic and Social Affairs estimates that by 2050 the world's population will have increased by over 2.1 billion people (UN DESA, 2019). Providing housing and infrastructure for them would essentially require building an amount equivalent to what currently exists. It is simply not possible to build in the future the way we do today. To appropriately confront the urgency of the environmental crisis, the building industry faces three immediate challenges: 1) reducing pollution, particularly embodied carbon emissions; 2) slowing the depletion of natural resources; and 3) minimizing waste production. The first challenge refers foremost to embodied emissions (De Wolf et al., 2013, 2016, 2017). The second challenge asks for a reduction in the demand of material used by the building sector, since currently 40% of global resource consumption results in the disappearance of essential virgin materials (OECD, 2018). The third challenge centers on what is wasted during and after construction. In the European Union, 25-30% of all waste produced by humans comes from construction and demolition (EC, 2018).

2. Strategies and Necessities for Change

Based on the arguments above, it should be abundantly clear that we need to change the way we design and build structures and that collective efforts are required.

One sensible approach is to design structures with much longer life spans, which can resist a wider range of loads and can be used for multiple functions. The philosophy here is to avoid demolition and the associated end-of-life waste. For buildings to retain their value, they should be designed to be more flexible and adaptable to avoid obsolescence (Cheshire, 2016).

An alternative approach is to achieve improvements for the impact of construction by designing structures that use fewer materials, allow more sustainable materials and are easier to recycle (De Wolf et al., 2016). Such structures are lighter and can be more easily disassembled when obsolete. This approach, however, challenges engineers and architects to rethink the way structures are designed and to strive for more efficient, less wasteful construction methods.

This section presents a) the principles that allow the realization of this latter approach, as well as b) the tools that the Block Research Group (BRG) at ETH Zurich has developed in pursuit of feasible solutions for practice:

a) Strength through Geometry and Material Effectiveness

"Strength through Geometry" means achieving structural performance by harnessing the power of well-thought-out structural design. Efficient structural forms, such as shells or vaults, can significantly reduce the required structural volume by placing material only where needed, i.e. by following the flow of forces for all loading cases. In particular, the use of funicular (i.e. compression-only) forms can, even with reduced structural sections, also significantly reduce stress concentrations thanks to their ability to uniformly distribute the load across their section, furthermore enabling the use of weaker and thus more sustainable materials (Ashby, 2013; Habert & Roussel, 2009).

Structural geometry also usually means a clearer understanding of the force-flow by the designer, who can thus separate compression and tension or strategically discretize the structure to control the structural behavior. This separation increases longevity and improves recyclability: easier access to the

components to be corrected for corrosion, fire, etc. better facilitates their inspection and replacement, and single-material systems allow us to easily discern material for recycling at a structure's end of life.

However, the geometry of a structure cannot be separated from its materialization: specific structural forms are more congenial to or even require specific materials; that is, certain materials should be used with certain geometries. Usually, engineers focus on material efficiency; in doing so, they often forget "material effectiveness". In other words, structural design often centers on the idea of optimizing the amount of material (efficiency), sometimes without questioning if that material is the right one for that application (effectiveness). We need to use a material for what it is good for.

Concrete is a good example of this. Depending on loading and boundary conditions, large parts of reinforced concrete elements do not contribute to the performance of the structure and are just additional dead load. One could question if, for spanning elements working in bending, reinforced concrete is indeed the right material and if other materials or structural systems should be adopted.

Figure 01: Mapungubwe Interpretive Centre, South Africa, 2008 and Rippmann Floor System prototype, 2016. The museum's tile vaults in soil-pressed tiles or the stiffened shell floor prototype are both thin, unreinforced structures using low-carbon-intensive material in very different contexts: soil-pressed tiles and concrete with a high percentage of recycled content. (Photos: Iwan Baan and Nick Krouwel)

b) Computational Design and Digital Fabrication

Achieving strength through geometry requires the structural designer to regain control of the geometry during the design process. Geometry is the universal language that connects the different fields of our industry, but in order to control it, traditional design tools are no longer sufficient, and new solutions are needed for both the design and analysis of structures. More importantly, the design process needs to change radically and to encapsulate structural constraints (and ideally many others, such as mechanical, fabrication, or construction constraints) from the start; the typical linear and iterative approach is no longer possible or even feasible!

Advanced analysis, design and drafting software are already available and in continuous development

(such as Grasshopper or Dynamo and their numerous plug-ins). However, in research as well as in practice, time and resources are wasted on connecting these software and setting up digital pipelines that often need to be completely reconstructed for each new project. The challenges for our industry to improve its impact dramatically are too big to be continuously reinventing the wheel. Instead, we need to join forces and work together to achieve a new status quo, sharing best-practice experiences in computational strategies. The Block Research Group's response to this is COMPAS, an open-source computational framework for collaboration and research in architecture, engineering, fabrication and construction (AEFC) (Van Mele et al., 2017).
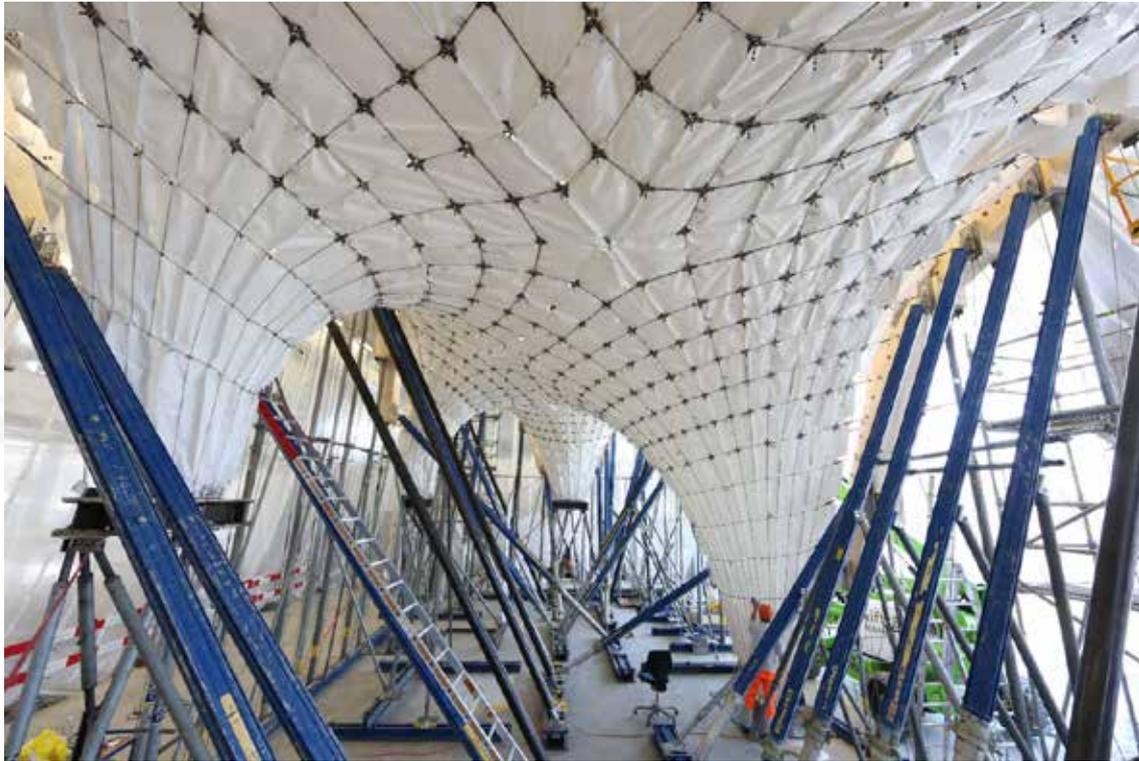
A: https://www.dropbox.com/s/3mio6snuk00jav2/HiLo_109_6J0A2753_Naida-Iljazovic.JPG?dl=0.

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B: https://www.dropbox.com/s/ecdoj3gom20u74e/HiLo_003_DSC_0102_Michael-Lyrenmann.jpg?dl=0.

Figure 02: NEST HiLo concrete shell prototype, ETH Zurich, 2017. The extremely thin concrete shell was cast on a flexible, fully reusable formwork system, getting its efficiency through the use of a pre-stressed cable-net. (Photos: Naida Iljazovic and Michael Lyrenmann)

To facilitate the interaction and exchange between researchers and practitioners from various fields in the AEFC industry, and the adoption and integration of the tools, expertise and methods of their respective academic or professional communities, the computational core of COMPAS is designed to be entirely independent of CAD software and (FEA) analysis tools. It provides flexible and robust data structures, numerical solvers, geometry processing tools, topology algorithms, robotics fundamentals, extensive file format support and transparent wrapping mechanisms for state-of-the-art external libraries that can be used to tackle a wide variety of problems related to virtually every aspect of the modern AEFC development process. Furthermore, through a unified scripting API and flexible serialization and data persistence mechanisms, the core functionality of COMPAS can be easily and consistently implemented cross-platform, not only in tools such as Rhino, Grasshopper, and Blender but also in distributable standalone applications and even cloud-based web apps.

Architecture lags behind other industries not only on the computational side (McKinsey, 2015), but also on the fabrication side. The means and methods of today's construction industry are substantially similar to those applied more than one hundred years ago. This affects productivity, quality, and waste production, especially for non-standard structures, such as structurally optimized geometries that need more efficient shaping strategies for their realization. Typically, the production of complex building components is slow and wasteful, but opportunities exist in digital fabrication technology including full-scale 3D printing, robotic assembly, or 3D knitting that offer fast, versatile and less wasteful means of automated architectural production (Rippmann et al., 2018, 2019).

Digital fabrication not only improves precision and quality, but it can also enhance productivity and engagement of labor (Orr, 2019). The smart input of digital fabrication strategies simplifies logistics and makes building sites more efficient. It may also enhance work options and opportunities for workers, giving them more interesting, engaging or challenging tasks.

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A: https://www.dropbox.com/s/6di9m2e3nceyk16/10_IMG_1500_Maria_Verhulst.jpg?dl=0

B: https://www.dropbox.com/s/a56l9bjg0yifzuy/Knit%20Candela-Angelica%20Ibarra-7.jpg?dl=0

Figure 03: KnitCandela, Mexico City, 2018 - BRG and ZHCODE with R-Ex. A lightweight 3D-knitted formwork offered a fast, extremely cheap and waste-free stay-in-place formwork for a concrete shell, finished by local Mexican workers. Photos: Maria Verhulst and Angélica Ibarra)

3. Conclusion

As the gravity of warnings concerning global warming and the health of our planet increases, we can no longer ignore the building industry's contribution to the crisis, nor can we continue to build in the same way we have for the last 100+ years, willfully ignoring the pollution and wastefulness caused by this model.

This short paper is meant as a 'call to action' for a better way of designing and building structures: we need to collectively work on new solutions to meet the environmental goals. Our architecture and structural engineering courses need to be revised to teach historic, often forgotten principles that value design acumen over material strength and to include more computation and digital fabrication skills. Our building codes need to change and equip engineers with tools to design more innovative structures.

The Block Research Group's research shows that when combined with the necessary computational and digital fabrication tools, principles like "strength through geometry" and "material effectiveness" can offer new opportunities to change our industry. However, many more strategies are needed for different contexts.

Finally, no change is possible if it is confined within the walls of a research institute and is not embraced by practitioners, contractors and developers. Whether it is for an iconic structure (such as a doubly curved, continuous shell roof) or one of the most common structural elements (such as a structural slab), architects, engineers, contractors, clients and developers, must investigate, adopt and promote more sustainable design choices. We have just about a decade to make a significant change! (IPCC, 2018).

Note

This paper is a summary of the paper by P. Block, T. Van Mele, M. Rippmann, F. Ranaudo, C. Calvo, and N. Paulson, "**Redefining Structural Art: Strategies, necessities and opportunities**", published in *The Structural Engineer* in January 2020. Through full-scale, built research demonstrators by the Block Research Group at ETH Zurich, this essay presents strategies, based on advances in computational structural design and digital fabrication, to take on these challenges, offering opportunities for a necessary disruptive change.

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LIQUID CITIES, a City Designed by Citizens

Rolf van Boxmeer, Tessa Peters,

Lucas van Leijdenstraat 31, 5213BB Den Bosch, The Netherlands

tessa@rezonethegame.nl, rolf@rezonethegame.nl

'The city of Sofronia is composed of two half cities. One is a large roller coaster with steep bumps, a whirligig with fanning chains, a Ferris wheel with rotating containers, a cylinder with steep wall riders with their heads down, a circus tent with a bunch of trapezes in the ridge. The other half of the city is made of stone and marble and cement, with a bank building, workshops, residential houses, the slaughterhouse, the school and everything else. One half of the city is huge, the other is improvised and when the time of the stay is up, it is taken apart, dismantled and taken to be transferred to the wasteland of another half city'

 __Invincible cities, Italo Calvino

Rezone wants to make the concept of the city more liquid.. A city where things can change, a flexible city that adapts to the desires of its inhabitants. A city designed by professionals, but also by its citizens. A city where roles are fluid and change. Where the designer becomes the builder, where the builder becomes the adviser, where the citizen becomes the designer. A constant flux and change of roles and structures.

Rezone creates open designs, methods and strategies where the influence of the end user is big. With new technologies, it is possible to create personalized designs and methods for everybody. For rezone, experimentation is an important aspect of the working flow.

Rolf van Boxmeer has a background in architecture and Tessa Peters has a background in the arts. The crossover of art and architecture brings new insights and is an activist methods and designs that can change the status quo in different urban fields.

In this short essay we will discuss four different projects on different levels of scale and use:

- Little babylon: interactive pavilion. People can influence the behaviour of the pavilion.

- Minitopia: a village build by its residents.

- Opensource housing, wikihouse: housing by everyone, for everyone.

- Redesire: an urban management game that gives people means to participate in urban developments at an early stage.

LITTLE BABYLON

Rezone, together with ONL architects, Air Design Studio and interactive designers from Lust, has developed an interactive and mobile pavilion named Little Babylon. The pavilion Little Babylon is an inflatable 'data-parasite'. It can be placed at random locations and festivals to collect data about the city it is located in. Little Babylon communicates this data with the audience in an interactive way as a dynamic, audio-visual show. It communicates and mixes the digital city with the physical city. It adds a digital emotional and social layer to a current urban condition. The pavilion 'mines' the internet for specific topics and translates this data in movement, visuals and sound, which together show the sentiment and temperament of the specific city.

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On a smaller scale Little Babylon also interacts with the audience that is present when they use their social media with e.g. specific hash tags. This unique experience communicates a blend of digital data and physical and dynamic architecture in an entire new fashion. It portrays, as a big three-dimensional data-visualisation, the moment-to-moment emotions of the citizens in real time.

The pavilion is a mobile and temporal architectural object that can be transported in a big bag to its destination and inflated in diverse urban conditions. It is equipped with three computer controlled (low-pressure) ventilators, 20000 RGB LEDS, audio, Raspberry Pi's and a networked connection. It mines the internet for relevant local searchterms, hashtags and RSS feeds. This data is translated into a dynamic spatial, visual and audial compositions. It knows emotional temperaments: the compositions represent the four Greek classical temperaments for the visiting city: sanguine, phlegmatic, choleric and melancholic temperament.

We live in a time that is dealing with the fact that next to a big physical urban condition and heritage we also live in and with a digital world. Little Babylon plays with what it means to deal with this digital world inside our current physical world and adds a new layer to the existing city. Since it is a highly actual topic nowadays, also in relation to the (re)use of the existing city, Rezone believes it is important to present and develop new architectural cross-over projects, like Little Babylon, to show new digital potentials and uses for current urban physical conditions.

The Four Temperaments:

As already mentioned, Little Babylon mines the internet for relevant local searchterms, hashtags and RSS feeds. This data is translated by an algorithm into four emotional temperaments: sanguine, phlegmatic, choleric and melancholic temperament. The four temperaments are expressed by Little Babylon through a composition of visuals, sound and movement. These are emblematic for the status of the visiting city. The temperaments are derived from the four fundamental personalities of ancient Greek philosophy.

Sanguine

The sanguine temperament is traditionally associated with air. Cities with this temperament tend to be

lively, sociable, carefree, open, and pleasure-seeking. They may be warm-hearted and optimistic. The city is imaginative and artistic, and is often open to many ideas. They can be flighty and changeable; thus, sanguine personalities may struggle with following tasks all the way through and be chronically late or forgetful. [16]

Choleric

The choleric temperament is traditionally associated with fire. A city with this temperament tends to be focused on itself and extroverted. It may be excitable, impulsive, and restless, with reserves of aggression, energy or passion, and try to instil that on other cities. The city tends to be focused on getting a job done efficiently. It can be ambitious, strong-willed and like to be in charge. A city with firm leadership and firm planning.

Melancholic

The melancholic temperament is traditionally associated with the element of earth. A city with this temperament may appear serious, introverted, cautious or even suspicious. It can become preoccupied with the tragedy and cruelty in the city and is susceptible to depression. It may be focused and conscientious and be less social.

Phlegmatic

The phlegmatic temperament is traditionally associated with water. Cities with this temperament may be inward and private, thoughtful, reasonable, calm, patient, caring, and tolerant. They tend to have a rich inner life, seek a quiet, peaceful atmosphere, and be content with themselves. Cities of this temperament may appear somewhat ponderous or clumsy.

MINITOPIA

Minitopia is a self-initiated project by Rezone. What started as an exposition of new sorts of flexible housing types, has grown into a full community of 30 experimental houses. More than sixty people live here in a new kind of 'light' community, where we have created a context involving a lot of room for self-building and creativity of the residents themselves. Rezone created an urban format that deals with less regulations, social and financial issues of smaller, affordable and flexible living.

The Minitopia site is located on the former waste disposal of 's-Hertogenbosch, Netherlands. This was once the place where the inhabitants of 's-Hertogenbosch could bring their waste. The waste

disposal service has now left the site and the empty site has been a waste area for several years now. It may not be developed in the next 5 to 10 years. Undeveloped land offers both good and great opportunities to develop housing in an affordable and light manner for 5, 10 or 15 years. Rezone started the Minitopia Foundation for this purpose. This foundation programs, directs, manages and exploits the site where a new collective of social housing is created with building systems, ready-made houses and self-builders. In addition, the foundation takes care of the financial management and is a contract partner to residents and the municipality. Rezone used an open and organic approach to this project, in which residents were given a great deal of freedom to build their own homes within a few spatial and urban development restrictions. In order to keep costs low we constantly try to use alternative and lighter ways of building, and to reuse existing materials.

OPEN-SOURCE HOUSING

De Wiek is a digitally produced house. Rezone has designed a small house built on the requirements of the prospective tenant, and based on the so-called Wikihouse system. Wikihouse is a globally available open source building system, which is created by Alastair Parvin and further developed online by the users of the system. With this building system, files can be downloaded, which then can be milled by the designer himself with a laser cutter or cnc cutter and assembled without large equipment or contractor. By designing houses through this system, we as Rezone can integrate design and production. Because design and construction come closer together, the result can be better controlled. It is also possible to go to a less traditional format where a different design is possible and the whole remains affordable.
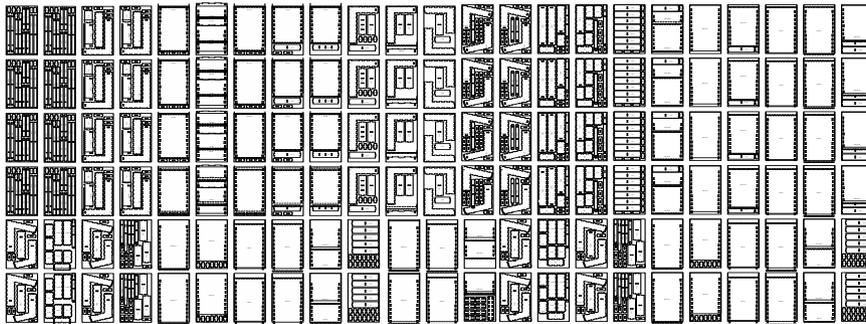
REDESIRE

Redesire is a digital interactive multiplayer game we developed with We are Muesli, a game design studio from Italy and Heijmans Vastgoed, a builder and developer from the Netherlands. It is developed with the intention to help various urban stakeholders understand and engage with each other's desires, wishes and expectations in fictional or actual area (re)development processes. The game always starts with a small fun game, to break the ice with the group. During the game, players sit around a table and use individual tablet computers in a series of turns in order to tease out and evaluate different ideas for the redevelopment of an urban site. Players are awarded with scores based on their performance both individually and as members of a stakeholder group. Their desires are evaluated and scored by other stakeholders. The main idea of the game is based on playing with words and concepts. Prior to the game, a list of keywords (desires and issues) is compiled by stakeholders. After that, during a series of opening rounds, each player alternates by choosing a single concept from the keywords. Players assess their concepts based on three criteria: beauty, usefulness, and feasibility. Other players assess this concept, too. After each round, players check whether the score of the concept 'owners' matches the scores given by other players. During their round, the players have the opportunity to change

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other players' opinions by writing compelling haiku and via discussion. The closer you get to the assessments of the other players, the higher your personal score is. The moderator who supervises the game, can start the conversation around the concept after each round. The game is played at the table with individual players or groups who each play a stakeholder's role. At the end of the game, besides players' individual scores, a map of desires is developed which shows players' evaluation of different concepts. In addition, there is an analysis of the game behaviour of each player. The main goal behind playing the game is to put various stakeholders, professional and non-professional, at one table in a safe way and that they can communicate in a common language.

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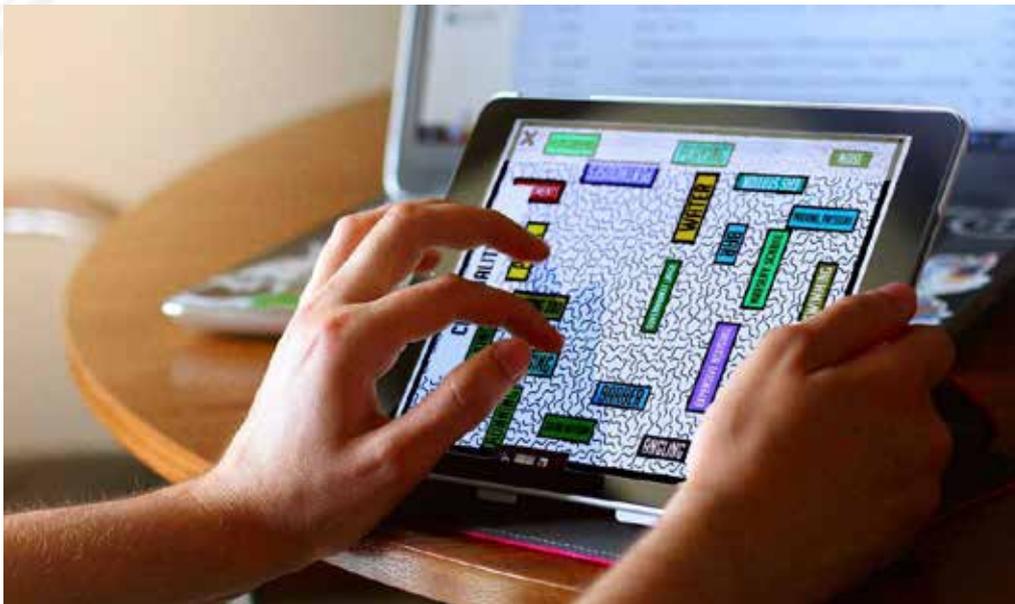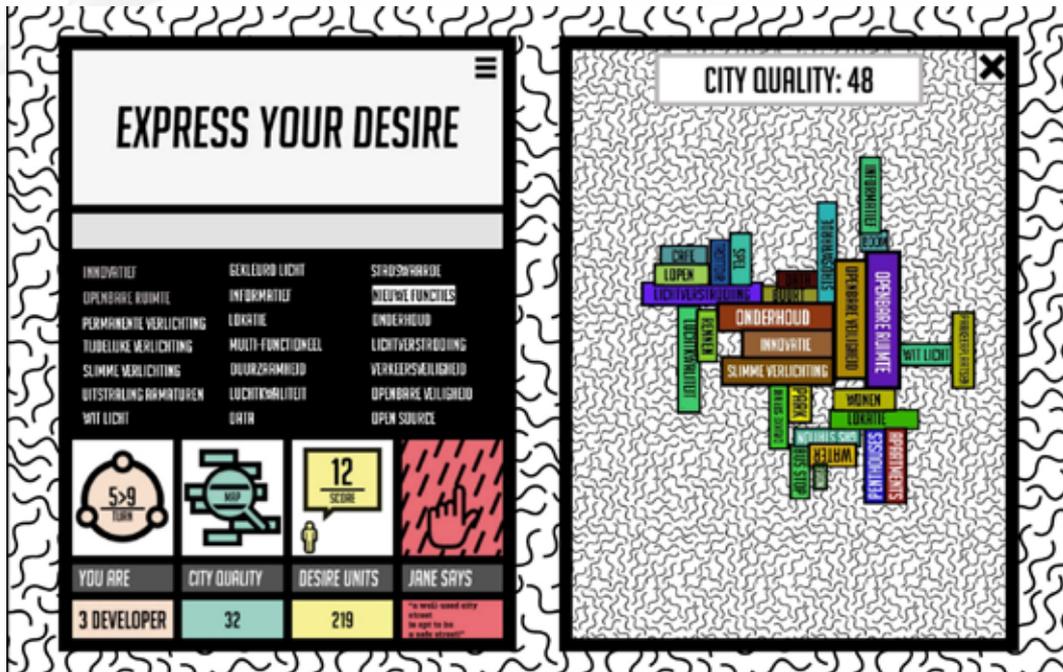
Rezone

Art & Architecture

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Cumulative, Collaborative, Disruptive
Architectural Geometry in Research, Practice, and its Imminent Mainstream Future

Vishu Bhooshan[1, 2], Shajay Bhooshan[1, 3]

[1] Zaha Hadid Computation & Design Research Group (ZHCODE), Zaha Hadid Architects, London.

[2] Architectural Computation, Bartlett School of Architecture, University College of London (UCL), London.

[3] Block Research Group, Institute of Technology in Architecture, ETH, Zurich.

[1]vishu.bhooshan@zaha-hadid.com
[2]shajay.bhooshan@zaha-hadid.com
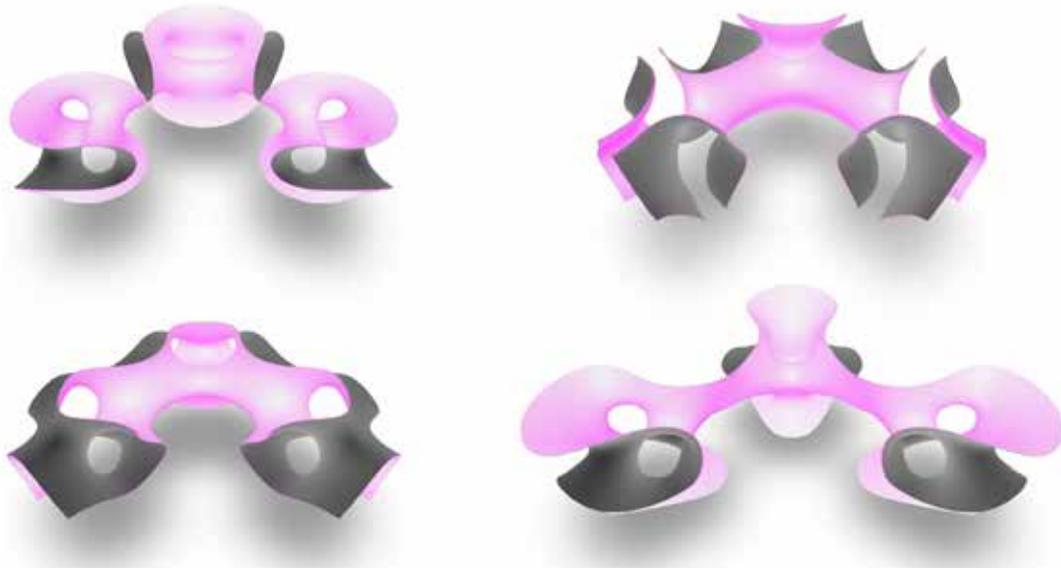
Figure 01: Realized design (Top) & various possible shapes of minimal surface for the central fabric pod (Below). Mathematics: The Winton Gallery, Science Museum, London (Zaha Hadid Architects). Photograph (Top) (c) Matt Danby.
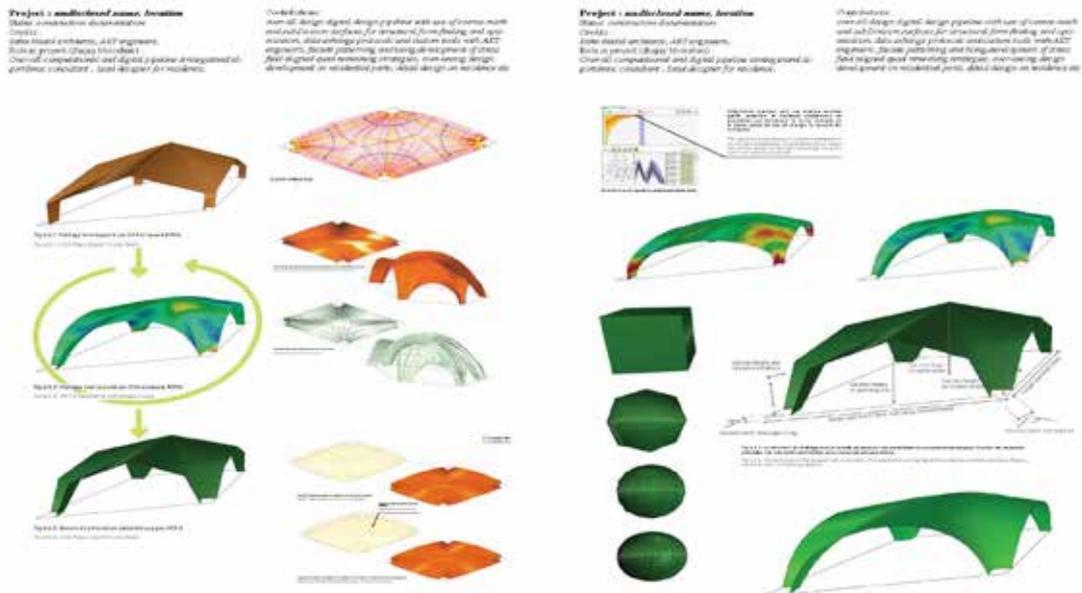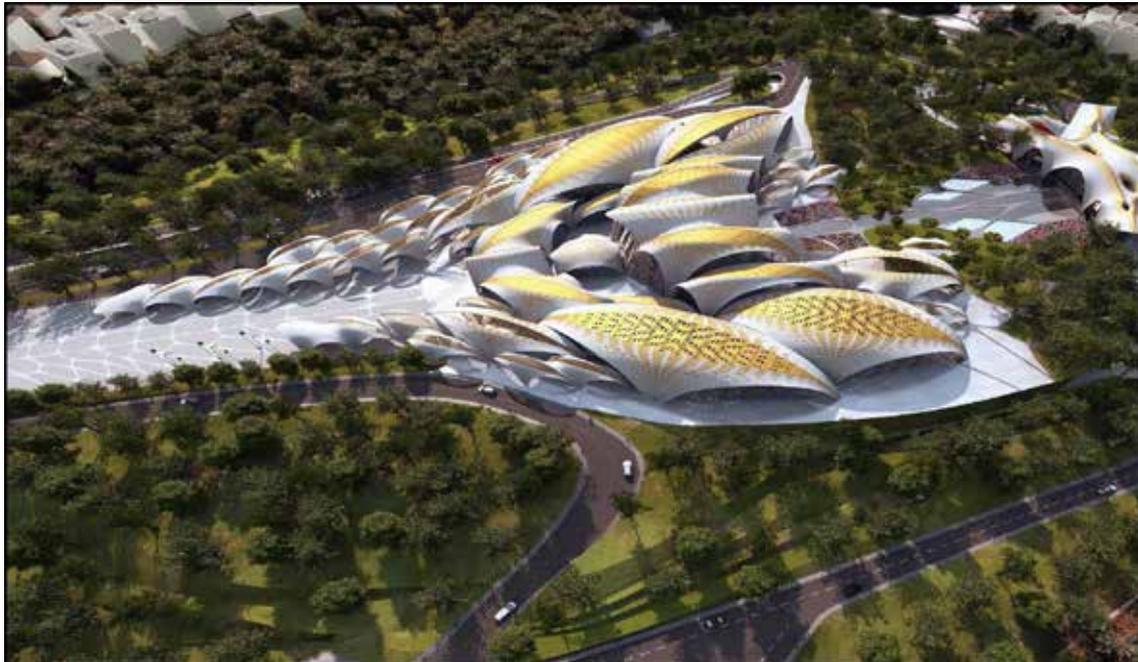
Figure 02: Collaborative workflow with the principal stakeholders of the architectural design process. Undisclosed Project (Zaha Hadid Architects with AKT II).

Solutions to the significant social, ecological and economic opportunities and problems of 21st century architecture and urbanism involve a vast number of variables. These solutions will require the use of data-driven technologies to acquire physical and social information of sites and consumer communities, digital technologies to design for the briefs so acquired and robotic manufacturing to deliver the designed solutions effectively.

In this context, *Architectural Geometry*[1] (AG) is a highly relevant design technology paradigm. AG focusses on the synthesis of shapes that guarantee structural and fabrication optimality. It is also closely aligned with and complementary to the development of robotic and digital fabrication (RDF).

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Further, in combining historical geometry-based methods of structural analysis, modern mathematics as used in computer graphics (CG) and computational technologies, the field is opening up several rich shape-possibilities that are also economically viable (Fig. 1).
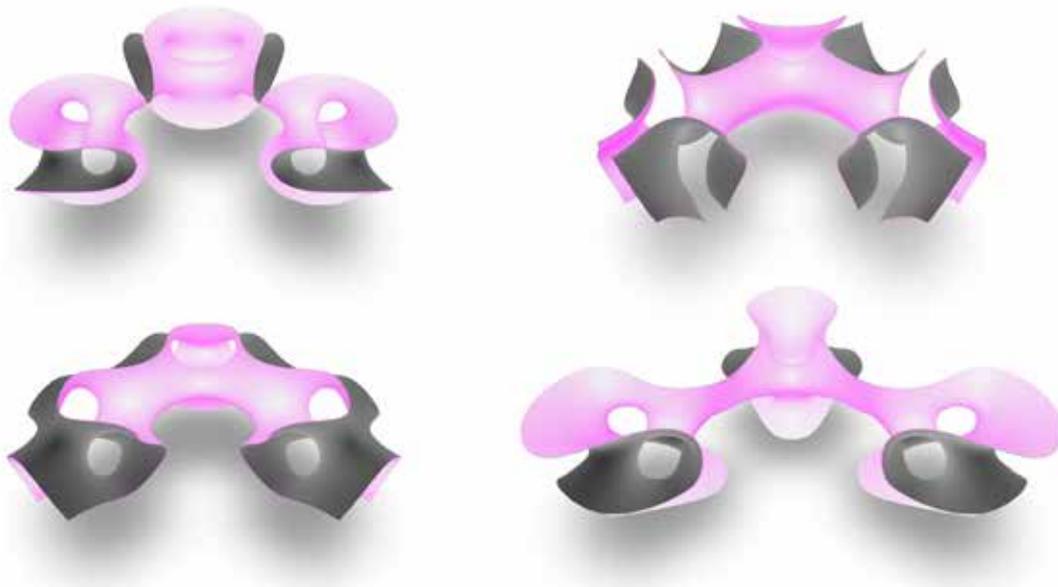
Design that is so digitally empowered is proving to be significantly more effective in terms of spatial expressivity and user experience[2], ecologically[3], preservation of building trades [4] etc. Thus, the recent and increasing popularity of AG is not surprising, considering it has brought the principal stakeholders in the architectural design process—architects, engineers & fabricators, and their respective tool-chains much closer together[5,6] (Fig. 2).

AG, despite its design benefits noted above, is currently expensive to make digitally as the creation of such geometries involves acquisition of considerable digital skills, development of toolsets that are either non-existent or unavailable within commercial design environments, creation of physical exemplars[5-11] etc. It is also expensive to make physically as the 20th century, automation-centric production systems are misaligned with structurally efficient, material conserving shapes of AG. AG is thus currently reliant on RDF and other early-stage technologies and methodologies for its physical realization[12, 6] etc. (Fig. 3, 4).

Figure 03: Prototyping of knitted fabric formwork with cast in-situ concrete shell (Top), Construction sequence, computational form finding and pattern generation studies (Bottom). Knit Candela, Mexico City (Block Research Group & Zaha Hadid Architects with Architecture Extrapolated). Photograph (Top) (c) Angelica Ibarra.

Parametric Design Detailing / Architectural Geometry
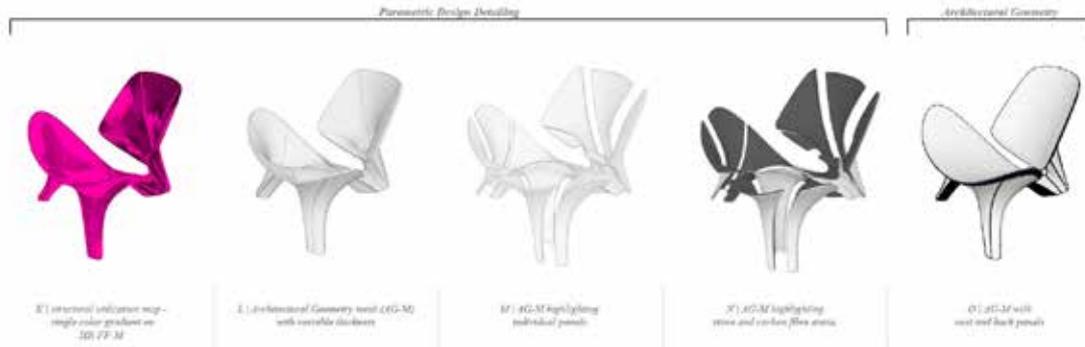
Figure 04: Prototyping of fiber reinforced stone chair (Top) and development of custom integrated tool chain (Below). Undisclosed Project (Zaha Hadid Architects & AKT II with New Fundamental Research Group & Generelli SA). Photograph (Top) (c) Generelli SA.

Efforts to overcome these critical cost obstacles are focused along two dominant vectors:

- *Improving creation and manufacture of AG designs:*

    The discipline of AG is consolidating the research and demonstration gains from its first decade of existence, and progressing towards full scale and mainstream architectural applications with ongoing efforts at the research epi□centers in Stuttgart, Zurich and elsewhere[13-15]. The maturation of several start□up businesses in RDF[16-18] along with the encoding of expertise in reusable code assets[19-21] for ease of creation and manipulation of AG, further reinforces this trend.

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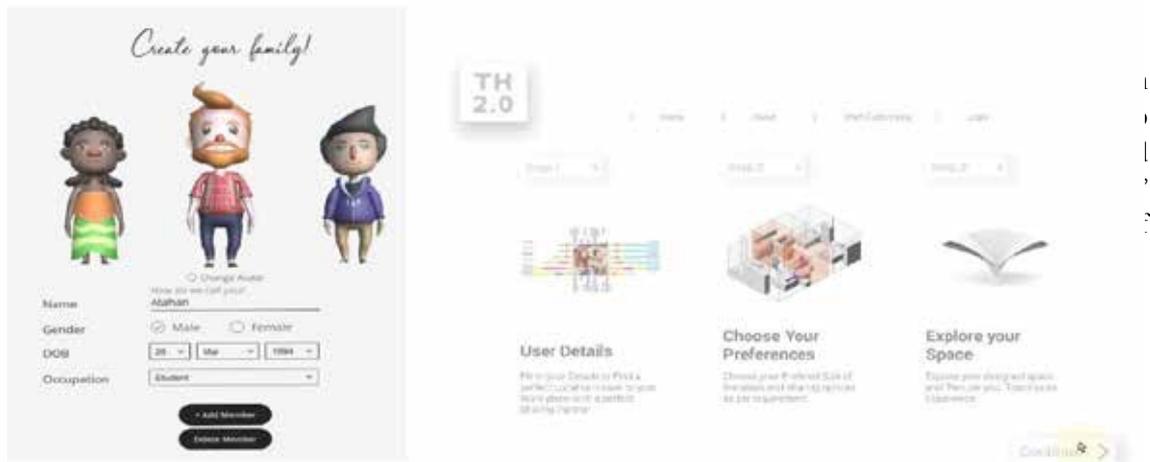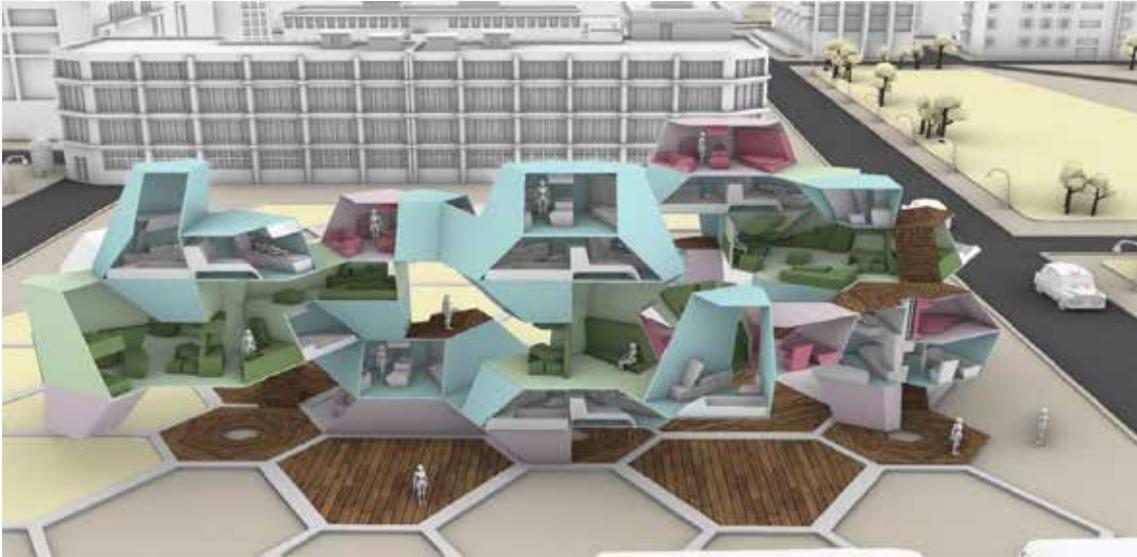
Figure 05: The community building game begins by constructing player profiles and inputting spatial and social interaction preferences. Subsequently, additional choices can be made whilst exploring the spatial choices (Top). A plausible state of the game after multiple players have made both physically related choices and social interaction choices such as sharing some spaces, exchanging others etc. (Middle). Players have the choice of choosing a location for their game-play, as well as the possibility of playing the game in Augmented Reality (Bottom). Game Play & Housing Configurator (Nahmad Bhooshan Studio, Architectural Association Design Research Lab (AADRL).

Figure 06: One of the outcomes from a particular instance of game-play was physically realized using the commercialized technology of Robotic Hot Wire cutting offered by Odico Robotic Formworks. This technology is now available as a 'factory-in-a-box' that can be shipped to various locations. The foam being lightweight also provides logistical advantages, apart from insulation properties. (Top) Computer generated view of an outcome from a particular instance of game-play, showing the variety of unit sizes and formal expressions, which nonetheless exhibit efficiencies

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in manufacturing due to digitized manufacture and assembly (Bottom). Game Play & Housing Configurator (Nahmad Bhooshan Studio, Architectural Association Design Research Lab (AADRL)).

AG, which is congenial with *Tectonism*[2, 23, 15]*,* has proven to be a highly effective technology-led design paradigm for the 21st century incorporating essential aspects of structure and fabrication in addition to increasingly encoding the social, ecological and economic parameters into the shape modeling process. The immediate outlook for AG is to significantly improve its prospects of mainstream impact - reducing the costs associated with its digital creation by in turn capturing and encoding the significant tacit know-how that is currently part of the creation process and thus its cost. Such a synergy already underway in the graphics community - Geometric deep learning[24] - would help further open the solution space and its exploration, whilst addressing the cost of digitally creating AG with potential machine assisted creation of AG, machine☐assisted tutoring of novice designers, institutional preservation or encoding of tacit know☐how etc. These, along with the rapid evolution of RDF technologies, would provide a sound basis for disruptive, industry-wide applications.

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The Extreme Structures of our Universe

Vincent Icke

Sterrewacht Leiden & Alien Art

icke@strw.leidenuniv.nl

My story is a tale of extremes. Extreme artificial structures that we have built on and around planet Earth. Extreme natural structures that exist in our Universe, and extreme structures in our mind, when we try to understand how this all works.

Of all the possible artificial structures, consider telescopes. The first one, invented by Johannes Lipperhey of Zeeland, was soon copied by Galileo Galilei, which dramatically changed our understanding of the Universe. The object itself did not look very dramatic, but its human impact was extreme. Currently, engineers in Chile are building the European Extremely Large Telescope, which will contain a segmented mirror with a total diameter of 39 meters. The building of this extreme instrument could more than cover the full grounds of the original Leiden Observatory, which is the oldest still operating observatory in the world.

Even more extreme in size are the modern radio telescopes, such as the ALMA interferometer, built for the European Southern Observatory in Chile. In such giant instruments, computer signals are used instead of steel girders and copper cables to connect the components. These are wonders of engineering. I find them much more impressive than the pyramids of the pharaohs, because our amazing scientific structures were built by free people for the benefit of all humanity.

Modern telescopes are carried into our Solar System by spacecraft, placing the wonders of engineering far outside planet Earth. They have observed our planets, their moons, and landed on many of them, revolutionizing our understanding of the history of our Solar System, and thereby the history of ourselves. Several such probes have already left the heliopause, and are heading for the stars.
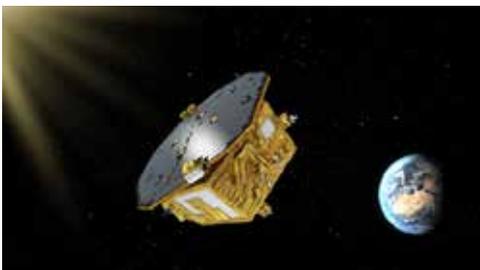
The next decade will see the launch of an even more exotic instrument, designed to detect the trembling of space-time caused by catastrophic collisions of compact cosmic objects. These tremors are called gravitational waves. The three spacecraft of the Laser Interferometer Space Antenna (LISA) experiment, built by the European Space Agency, will be linked by lasers over millions of kilometers. These structures are among the most extreme that have ever been built, because even though they are only a few meters in size, they are precise enough to detect displacements of the size of an atom, one hundred billion times smaller than a human being. With this sensitivity, LISA can detect gravitational waves throughout the Universe.

Let us now look at natural structures, the shape and disposition of the things that the world is made of. First, consider the structure of matter. The extreme structures are found way below the more or less everyday scales of atoms and molecules. It is amusing that some of the biggest instruments have been built to study the smallest particles we know. The ATLAS detector built at the European Center for Nuclear Research (CERN) is housed in an underground cavern about 40 meters high. It is 46 meters long, 25 meters in diameter, and weighs about 7,000 tons; it contains some 3000 km of cable.
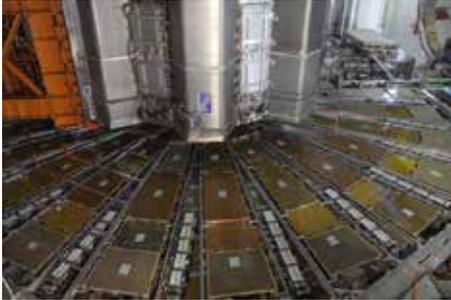
The purpose of this imposing machine, one of the focus points of the 27-kilometre underground tunnel ring of the Large Hadron Collider, is to study the structure of matter on the smallest attainable scale. At present, the giant CERN collider has probed the structures of particles to sizes that are ten thousand billion-billion times smaller than a human being. It would not be helpful to try and make images of these structures, because they are so totally extreme that we are incapable of recognizing or appreciating them. Mathematics will do the job. Nevertheless, every image of whizzing balls and flashes does not do justice to this extreme world, and is no better than a story, one that would at best give a false feeling of familiarity.

Totally on the other side of extremes are the most distant structures we have ever seen: young groups of stars near the beginning of the Universe. These flecks of light are not stars but galaxies, each one containing a hundred billion stars or more. The faintest are about 11 billion light years away from Earth, which is almost billion-billion-billion times more than the size of a human being. That is about as far as we can see at present, because the age of the Universe is 13.8 billion years, wherefore we cannot observe anything beyond that distance.

Detailed observations of such galaxies show even more surprising structures, made of something we cannot even see. This blue ring of light is actually a single compact galaxy at immense distance, seen through a huge mass of dark stuff assembled around the bright galaxy in the center of the ring. The matter of the foreground galaxy curves space, so that it acts as a kind of magnifying glass, casting a distorted and enlarged image of the galaxy in the background. This is called the 'gravitational lens effect'. Sometimes this mass is referred to as 'dark matter', but that is presumptuous: we do not know what it is, and there is no evidence that it is even related to the particle-based matter that we are made of. Observations indicate that the most extreme structures in our Universe are made of this dark stuff, which composes about 95% of the content of the Universe – and we have no idea what it is.

If dark stuff is made of some kind of particles, the way ordinary matter is, then we can say: the structures in our Universe are made of particles, space, and time. We must learn to understand these. So we must build theoretical structures, analogous to the mechanical structures of our giant telescopes and immense particle accelerators. The structure of matter is extreme. Therefore, our theories are also extreme. The theory must cover everything we observe about particles, space and time, the extreme building materials of our Universe.

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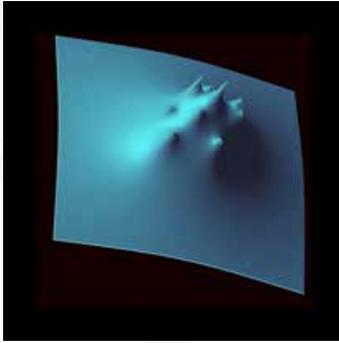
Space-time is real, just as real as concrete and steel. Space structures occur naturally, because matter curves the space around it. Just as in the case of origami, where the folding process determines the shape. For example, the matter of every star curves space, and this curvature we experience as gravity. Therefore, in a sense, gravity does not exist: it is an historical term for the consequences of the structure of space-time. Curved space makes curved orbits. Orbits in space show us what the structure of space-time is. In this way, the orbits of stars in the center of our Milky Way galaxy tell us that the space structure there is so extreme that no light can escape from the centermost area. This very extreme space-time structure is what we call a supermassive black hole.

The shapes that space curvature produces are connected with the shapes of material orbits. The elliptical orbits of the planets are a well-known example. These orbits are so plain and simple because of the almost perfectly spherical shape of the space around the Sun. Much more complicated orbits are followed by the stars in colliding galaxies.
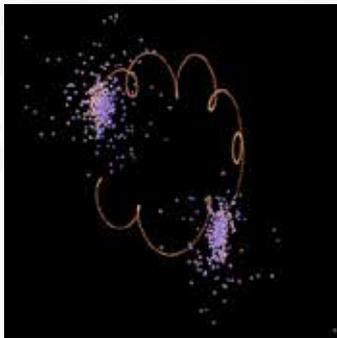
The biggest and most extreme material structures in the Universe are the conglomerates of galaxies and their surrounding dark matter. The Universe expands, because in the course of time space itself expands. Thus, the expansion of our Universe on large scales (beyond a hundred million light years, say) is not a case of matter moving through space, but space itself moving, in the sense that the amount of space in the Universe increases. But the initial distribution of matter, starting 13.8 billion years ago, was not exactly uniform. There was a certain cosmic noise, very similar to low-intensity sound waves. Thus, in the beginning there were small patches where the mass density was smaller than average and others where it was bigger. The deviations from the mean were infinitesimal: only one part in a hundred thousand.
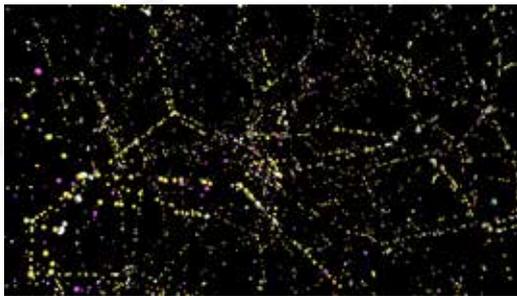
The patches with a below-average density expand a little faster than the average Universe. This produces a distribution of bubbles, from which matter flows away, accumulating on the walls between the bubbles. Where those walls intersect, filaments form, which in turn end up in nodes where four filaments meet. It is possible to approximate this flow of matter in our expanding Universe using a mathematical formalism published in 1908 by the Ukrainian mathematician Gyorgy Voronoi, called a *Voronoi tessellation*. The resulting extreme distribution of matter is currently called *cosmic foam*.

Cosmic structures are always dynamic. Gravity always asserts itself in the long run. Even those that seem static are so only on a human time scale. Seen with a time lapse of millions of years, everything is in constant and often violent motion. Still, I call these things *structures*, even though they are only snapshots in the history of our Universe. But that is also true in the case of human structures: what spectacle would the Egyptian pyramids show with a time lapse of centuries?

A similar dynamic holds in the case of our mental structures. These also evolve, but on a human time scale. The mental structures we have developed for understanding the Universe have also become

more and more extreme. Even classical mechanics is not trivial, and quantum field theory and general relativity are yet more extreme. I think that probably our future understanding of the interplay between matter, space and time can fairly be called an extreme mental structure. These extremes we cannot avoid when we try to understand how the Universe works. It is well known that our Universe is extreme, if only in the sense that it is so vastly different from our human scales of mass and size. The search for these extreme mental structures – one may call them theories – goes on forever, because there is so much more to grasp and to understand.

Is there an ultimate theory? A mental structure that is, in a sense, the most extreme, because it encompasses all the phenomena in the Universe? A 'theory of everything'? Of course, we do not know, but I think that it is improbable. What unites particles, space and time? We observe their structures, but what is the underlying mental structure, the theory? We are doing very well on both extremes: elementary particles that are unspeakably small, and the Universe that is extremely big. Should we try to connect these extremes? If we must, can we do it? I wish that we had the answer. Maybe this is the structure that dreams are made of.
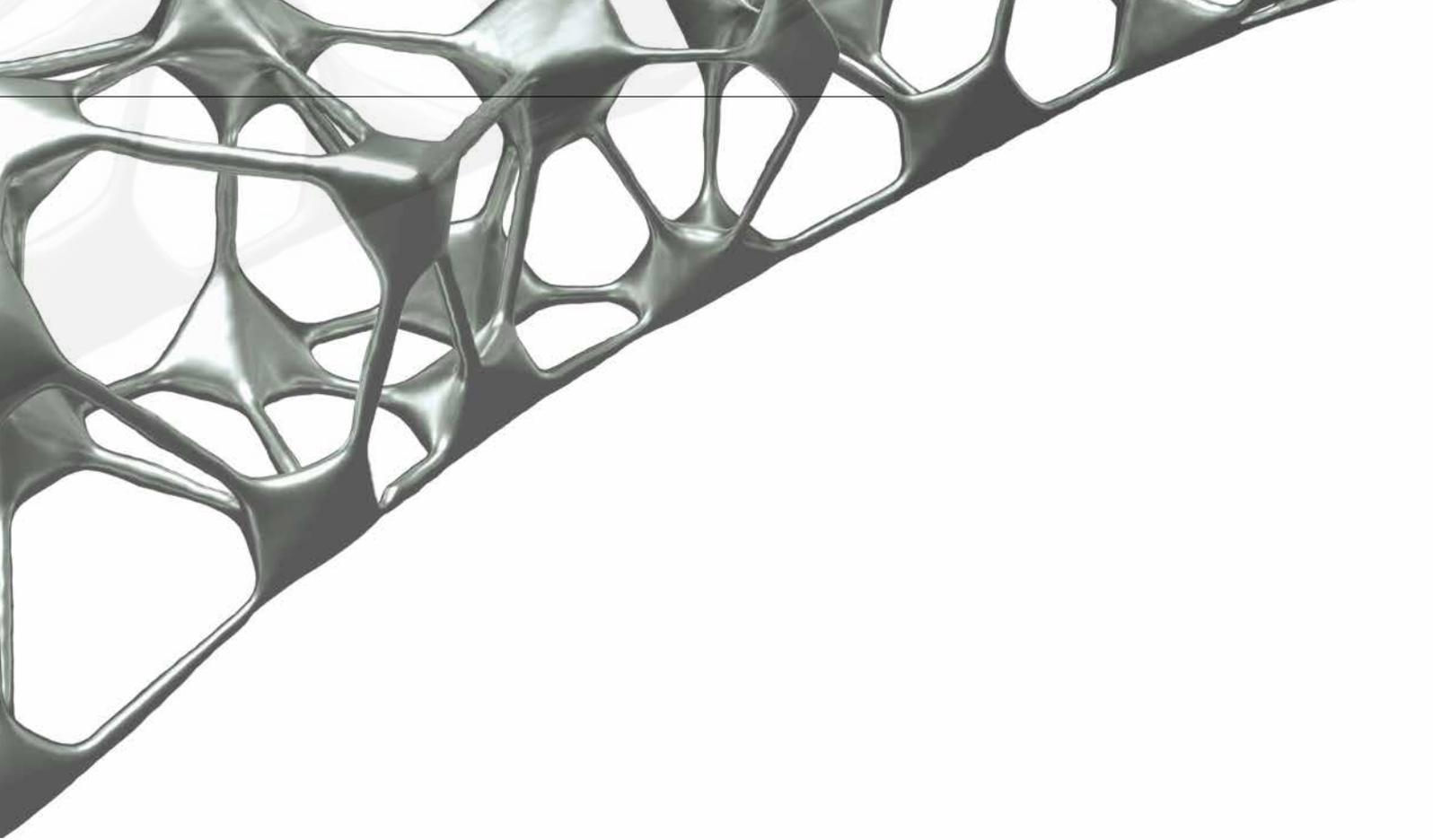
Part III: Abstracts

Urbanism Beyond Cognition: On Design and Machine Learning

Roberto Bottazzi

University College London, United Kingdom

roberto.bottazzi@ucl.ac.uk

Abstract

It could be argued that the introduction of new technologies always shifts the 'epistemological horizon' of the different fields they impact. New instruments allow expanding the range of parameters defining a discipline's working methods which in turn change their very definition. Design is no exception: for instance, the promises delivered by increases in data collection capacity and early computers helped Buckminster Fuller to redefine design as a planetary activity operating over large timeframes. Today the massive data storing capacities and the improvements on machine learning algorithms to mine them represent the latest development in this long series of epistemological turns. Though little design work has been occurring in this area, there is already an implicit emphasis on efficiency, which may hinder the development of more conceptual and cultural aspects of automated design.

The paper will unravel such issues by discussing the design experiments carried out in the Master in Urban Design at the Bartlett, as way to expand conversations between automation, architecture, and design. Particularly, the emphasis will be on how machine-learning algorithms open design up to spatial elements that either are beyond human perception or currently downplayed in the design process. From climate change to rapid urbanization, the speed and scale of urban transformations call for an expanded conceptual framework in which automated design processes allow us to question received classifications based on type, programme, etc., pushing the design towards more complex, fluid, open, incomplete, and embracing urban proposals.

Keywords: Machine learning; Urban design; Big data

Fundamentals of Robotic Fabrication in Architecture: Multi Materiality, Multiscale Resolution and Multimode Production

Sina Mostafavi[1], Mohammad Saad Moharram[2], Adeeb Khaeez[3]

[1]TU Delft & Dessau Institute of Architecture, Netherlands

[2,3]Dessau Institute of Architecture, Germany

[1]s.mostafavi@tudelft.nl

[2]mohamed.s.h.s.moharram@student.hs-anhalt.de

[3]Adib.khaeez@student.hs-anhalt.de

Abstract

This paper discusses the recent advancement in architectural materialization processes. The focus is on design to robotic production systems through which the realization of more efficient building processes and building products is achieved. Introducing three prototypical case studies, the research specifically addresses some of the major fundamentals of robotic production in architecture. Considering the fact, that building systems have consisted of numerous subsystems each with varying requirements, hybridity or multi-materiality is essential in architectural design. Therefore, computation to production of efficient hybrid systems with multiple materials is tested and prototyped in a series of case studies. The introduced multilateral system is a hybrid of concrete as the structural material and expanded polystyrene as the second substance. Beyond the description about computational design, digital modeling and robotic production methods, this project highlights how through using robotic production the process of mold making and concrete casting is re-examined. The second topic is the resolution, which is about simultaneous design to production in multiple scales, ranging from micro to macro. This is elaborated and prototyped in a case study on incremental metal forming. In this project, the very micro scale manipulation of bendable thin sheets of metal results in stiffness according to the design requirements. The last subject is explained in design to robotic production of a customized table with numerous components in expanded polystyrene that will be coated in fiberglass. In this design, multimode robotic production methods are implemented according the curvature analysis. As a result, the evaluation of the efficiency of the production process is feedback to design process in which hot wire cutting is applied to single curvature surfaces, while robotic milling is only applied where needed. Providing more details about the projects, the paper will conclude with a framework on fundamentals of robotic production in architecture.

Keywords: Architectural robotics; Multi materiality; Hybridity; Multiscale resolution; Multimode production; Incremental metal forming

Shared Models and Open Infrastructures for the Smart City Internet of Things Based on the Semantic Web

Mouad Banane[1], Abdessalam Belangour[2]

[1,2]University Hassan 2, Morocco

[1]mouadbanane@gmail.com

[2]belangour@gmail.com

Abstract

Contemporary cities face many challenges: energy, ecological, demographic or economic. To answer this, technological means are implemented in cities through the use of sensors and actuators. These cities are said to be smart. Currently, smart cities are operated by actors who share neither their sensor data nor access to their actuators. This situation is called vertical: each operator deploys its own sensors and actuators and has its own IT infrastructure hosting its applications. This leads to infrastructure redundancy and ad-hoc applications to oversee and control an area of the city. A trend is to move towards a so-called horizontal situation via the use of an open and shared mediation platform. Sensor data and access to the actuators are shared within this type of platform, allowing their sharing between the different actors. The costs of infrastructure and development are then reduced. This work is part of such a context of horizontalization, within an open and shared platform, in which we propose: 1) a layer of abstraction for control and supervision of the city, 2) a competition control mechanism handling conflict cases based on the RDF (Resource Description Framework) semantic Web standard, 3) a coordination mechanism promoting the reuse of actuators using ontology, 4) an implementation of our work by a proof of concept. The abstraction we propose is based on models from reactive systems. They aim to be generic and represent the invariant of the smart city: the physical elements. They allow applications to control and supervise the city. To facilitate the development of applications we standardize the interface of our models. Since these applications may have real-time constraints, especially those that have control objectives, we propose to take advantage of the distributed architecture of this type of platform. Given the sharing of the actuators, we have identified that conflicts can arise between applications. We propose a mechanism of competition control to deal with these cases of conflicts. We have also identified that a coordination mechanism must be offered to applications wishing to perform atomic control operations. Such a mechanism promotes the reuse of the actuators present in the city. Finally, we implemented our proposals around a proof of concept, including several use cases, to demonstrate our work.

Keywords: Smart city; Semantic web, RDF

Adaptive Architecture, an Implementation with Game Theory. Emotional Input and Pneumatically Driven Actuator

Yann Blanchi[1], Corinne Touati[2], Elizabeth Mortamais[3]

[1,3]EVCAU Laboratory, School of Architecture of Paris Val de Seine, France

[2]INRIA Grenoble, France

[1]yann.blanchi@paris-valdeseine.archi.fr

[2]corinne.touati@inria.fr

[3]emortamais@gmail.com

Abstract

In the active context of adaptive architecture, this proposal tackles the field of Human Building Interaction. Indeed, material would no longer be inert but activated by the users, programmable and equipped with memory. The information chain penetrating each component of the house forms a field of globalities. On the one hand, in line with the under development of smart materials, giving intelligence to previously passive materials, we consider the pneumatically driven actuator material as soft robot and programmable and on the other hand, we implement swarm communications with means of innovative IT elements. Since the elements of the smart material are interdependent, we consider a novel approach of modeling their interactions, using tools from the vast field of game theory. The digital information travels gradually through the physical material. In a technical point of view, first, we expect that a pneumatic cells network could be considered as a Human Building Interaction. HBI could operate using both remote and haptic information, one constituted by emotional records, the other reacting to the physical contact. We focus on the emotional implementation and the haptic inputs, within a pneumatic cells network actuator. We considered both, inhabitant emotion and kinesthetic communication as inputs and we implemented pneumatically driven actuators. The pneumatic cells network is used as a soft changing interface, a dynamic architecture that links the building with the inhabitants, an architectural apparatus that supports an active process in a changing way. A program that can be described as a multi-player game addresses the pneumatic cells network.

Keywords: Human building interaction; Game theory; Pneumatic cells network

Design as Semiosis: A design Mechanism for Place Branding

Eirini Krasaki

PHD Candidate at National Technical University of Athens

eirini.krasaki@googlemail.com

Abstract

The described design methodology combines parametric design, data analysis, algorithmic design and semiotics theory to systematically analyze urban reality. The analysis leads to a creation of a nebula of data which corresponds to the place of interest. The nebula of data consists of networks of semiotics spatially defined. Through the proposed methodology, semiotics are used to enhance the perception that we have for a place and create a strategy for its' branding.

Space is not approached as an empty container but as a complex system that consists of material and immaterial elements. The characteristics of these elements are quantified by their context and the logics of description to which they correspond. Logics of description are constantly changing following the multiplicity and the expansion of concepts. Therefore, space is constantly redefined following the transformation of the corresponding virtual data.

Considering that each framework draws up an ideology following the change of context and the logics of description, a tool (machine) for analyzing written speech is developed, combining data visualization techniques, linguistics and design methodologies to configure logics of description. Written speech is transformed into a series of networks, visualizing their ontological relationships and disregarding the factor of time. A nebula of data corresponding to the mental reality of space is formed. Following a methodological procedure, the nebula of space is transformed to a nebula of place. The nebula of place contains its' key characteristics parametrized. A selection of these characteristics is combined to create the brand of the place concerning its' context and logics of description. The before mentioned methodological tool connects people, spaces, and machines enabling the connection of spatial data to create the impression (brand) of a place.

Keywords: Digital technique; Spaces; Machines

Using the Fractal Dimension to Generate Parametric Islamic Patterns

Mai Abdelsalam[1], Hassan Abdelsalam[2]

[1]Alexandria University, Egypt

[2]SAK Holding, Qatar

[1]maiabdelsalam@gmail.com

[2]muzarc@gmail.com

Abstract

Non-communicable diseases (NCDs) are the cause for over 70% of global deaths. Various levels of healthcare delivery from home-care to tertiary care exist for patients where patients with NCDs are treated. Demand for services provided by tertiary level institutions has increased tremendously along with the growth and prevalence of chronic diseases. Few of the other reasons include co-morbidities, greater complexities of diseases, greater public expectations, higher life expectancy, an aging baby-boomer population, identification of diseases at later stages of life and deferral of care among many other complex scenarios.

Globally, rising demand for healthcare services presently sets challenges of under-capacity and under-staffed healthcare infrastructure. With the advent of technology in healthcare and by providing tools in the hands of patients, a shift in healthcare delivery is evidenced towards early detection of diseases and prevention as a means of patient-care and for tackling non-communicable diseases. Evidence based delivery models tend to focus on patient experience in the course of treatment. This has consequences on the physical spaces where care is delivered, as the focus shifts from the space to the patient.

This paper explores how greater demand to address prevalence of non-communicable diseases and the advent of technology can create opportunities for development of healing spaces. For patient-centric care, this would entail from inclusion of technologically driven healthcare environment within a home-care setting to improving the functional efficiencies within existing and proposed tertiary level hospitals for patient-centered care.

The notion of bringing hospital (healthcare) to the patient is becoming a necessity to create a future where patients would depend less on the model of in-efficiently functioning tertiary level hospitals and a greater effort will be required towards home-settings, applying the adage 'prevention is better than cure.'

Keywords: Healing spaces; Active technology; Passive technology; Patient-centric care; Patient-centered care

وقائع مؤتمر العمارة الدولي الرابع، قطر 2019 – [GSM4Q]

أحمد محمد أحمد، فضيل فاضلي، كاس أوسترهويس (محررون)

يتناول مؤتمر Game Set and Match IV Qatar [GSM4Q] فلسفات، واستراتيجيات، واتجاهات جديدة نحو مهارات التفكير الإبداعي ثلاثي الأبعاد لصناعة الإنشاءات الرقمية، لعامة الناس المصنفة على أنها "ربط الناس بالمساحات والآلات".

طرح المؤتمر وسائط مهمة لنشر أحدث التطورات المبتكرة في مجال الهندسة المعمارية. وقد كان المشاركون في المؤتمر من المهنيين الممارسين والطلاب.

يهدف المؤتمر إلى إلهام وتحفيز صناعات وخبراء البناء في قطر؛ لتبني الأساليب الربوتية والآلية الجديدة في التصميم والتصنيع والبناء. بالنسبة إلى الصناعات القطرية، كان ذلك يعني تحولًا وتقدّمًا نوعيًا في التوجه نحو الرقمنة، والتفكير والتصميم والتصنيع ثلاثي ورباعي الأبعاد؛ من أجل تعزيز الصناعات الجديدة وتشجيع المزيد من التنويع الاقتصادي.

الموضوع الرئيس لمؤتمر هذا العام هو "ربط الناس بالمساحات والآلات"، وموضوعه الفرعي"الجوهر المستوحى من التراث". وقد قسمت موضوعات المؤتمر في إطار قابلية التوسع في تشكل علاقاتٍ بين المكونات الجوهرية؛ حيث جرى تناول الموضوعات الرئيسة خلال جلسات المؤتمر، وهي 1] التجمعات البدوية التقليدية، 2] المدن والمباني التراثية، 3] البدو والجوهر الفريد، 4] حراك في سبيل التطوير، مع رؤية شاملة تجمع بين الأصالة والمعاصرة. بما يمثل طبيعة شكل المباني للجيل القادم.

كانت جلسات اليوم الأول "التقليد" بعنوان "الكون/الكوكب"، في حين ركزت جلسات اليوم الثاني "الجوهر" بصورة أكبر على أحدث مداخل المباني في مدينة الدوحة وغيرها من المناطق.

Proceedings of the International Conference on Game Set and Match IV Qatar-2019 [GSM4Q]

Editors: Ahmad Mohammad Ahmad, Fodil Fadli, Kas Oosterhuis

The GSM4Q conference addresses new Philosophies, new Strategy and New Directions towards 3D Creative Thinking Skills for the Digital Construction Industry, for the public framed as "Connecting People Spaces and Machines".

GSM4Q offered an important vehicle to disseminate the current most innovative developments in the åeld of architectural engineering. The participants of the conference, both practitioners and students.

GSM4Q aimed to inform and stimulate the Qatar based construction industries and their experts to adopt the new robotic methods of design, manufacturing and building. For the Qatar industries, it meant a further shift of focus towards the digital and towards 3D and 4D thinking, designing and manufacturing, as to promote new industries and encourage further economic diversiåcation.

The theme of the Game Set and Match IV Qatar [GSM4Q] conference is "Connecting People, Spaces and Machines", with as the subtheme 'The Informed Nomadic Monad'. GSM4Q topics were structured along the lines of the scalability of the connections between constituting monadic components. Leading themes for the conference sessions are 1] Informed Nomadic Swarms, 2] Nomadic Cities and Buildings, 3] Monads and Nomads, and 4] Scalable Interaction with **Inclusive approach with respect to tradition and modernity,** but representing the natural form of the next generation building.
Day One The Nomad session labelled "Universe / Planet" and **Day Two The Monad** focused more on the realized state of the art buildings in Doha and elsewhere.