[SɪS]

KINE[SɪS]TEM

FROM NATURE TO ARCHITECTURAL MATTER
INTERNATIONAL CONFERENCES
JUNE 19TH - 20TH 2017, LISBON, PORTUGAL

CONFERENCE PROCEEDINGS

Foreword

Architecture creates artificial environments that host human activities and mediate the interplay with nature. Traditionally, this dynamic interaction was assured by static strategies well established throughout the history of human settlements and anchored to local nature and culture. First generation technologies like mechanical heating and cooling, or electric lighting, brought a false sense of control that led to a progressive decline of the awareness of nature. Previously consolidated knowledge and paradigms have been upset by new challenges and opportunities coming from technological innovation as well as cultural developments that respond to new perceptions of the conceptions and relationship between natural and artificial environments.

The Anthropocene and subsequent eras explode limits between human and non-human existence. In the last thirty years we have seen nature become a tool, a model and now a culturally blurry definition.

Anchored in its relationship with inhabitability, Architecture evolves criteria typical of a mediator - between environmental concerns, cultural and social forms, material paradigms and innovation and the pleasure of invention and discovery of new tectonics of articulation.

How can architectural systems moderate across all these factors while attending to the varying expectations of response? This is the starting question for the Kine[SiS]tem'17 – From Nature to Architectural Matter International Conference. Kine[SiS]tem – From Kinesis + System. Kinesis is a non-linear movement or activity of an organism in response to a stimulus. A system is a set of interacting and interdependent agents forming a complex whole, delineated by its spatial and temporal boundaries, influenced by its environment. Today, the argument for a holistically responsible and relevant architecture requires very effective strategies that can respond in a multidimensional way.

The challenge ahead requires design processes that are built upon consolidated knowledge, integrate and co-develop innovative technologies and seek inventiveness on and in the articulation with so called natural systems.

Zero-energy buildings are a crucial desired part of architecture systems for the 21st century and solar radiation is one key factor in low-energy thermal comfort. Computational-controlled sensor-based kinetic surfaces are one of the possible answers to control solar energy in an effective way, within the scope of contradictory objectives throughout the year. To develop such shading systems, inspired by natural patterns and assuring a low-cost production is the objective of the summer school following the international conference. The Kine[SiS]tem'17 – Shading Systems Summer School will integrate master classes, design studios and prototyping workshops. The Master classes will cover four themes: Sustainability, climate and solar radiation; Nature-based parametric patterns; Performance-based design; Digital fabrication. The Design Studios will explore the use of Grasshopper, Ladybug and Honeybee as creative and technical tools, from simulation to prototyping 3D responsive architectural solutions.

The summer school is intended for students and professionals from different areas of knowledge – architecture, design, fine arts, engineering, and programming, who are interested in the process of design: from ideation to prototype.

We acknowledge all the researchers sharing their work in the conference and express our deep gratitude to the four distinguished keynote speakers for their invaluable contribution to this common reflection on new and exciting paths to achieve human inhabitable environment criteria while being in an intelligent, exploratory and responsive dialogue with the much larger and broader natural ecosystems.

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Index

Digital Fabrication in Education: Inside An Emerging Design Program
Louay Youssef

Re-morphing the Amorphous - Creating New Urban Substance
Yannis Zavoleas

*A Study on the Materialisation and Formation of Mycelium in
a Fabric Formwork*
Gulay Elbasdi, Sema Alacam

Growth as the Morphological Generator of Biological Identity
Ricardo Massena Gago

Heliotropic Nature's
Mary Polites, Maddalena Belle, Marida Maiorino, Raquel Paramo, Brandon DiFalco,
Carmo Cardoso

Design as an adaptive time-scape
Susannah Dickinson

*The built environment as an extension of human biology
Alexander, Damásio, Bratton*
Diana Soeiro

Re-morphing the Amorphous

Creating New Urban Substance

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Abstract. This paper pertains to a broader research area wherein systemic references are employed to inform spatial articulation, operations and overall behavior in architecture. Design is approached as a dynamic process in analogy to ones invested in nature, being about energy exchanges causing interactions and transformations of the parts and the whole. For this particular study, "amorphous" phenomena of the urban context are activated and further manipulated towards spatial propositions through methods and techniques described as "re-morphing." Concepts from geology and biology have been borrowed as an asset of ideas, organizing patterns and formational strategies, assisting to develop alternative ways for interacting with the urban milieu.

Keywords. *Dynamic Simulation; Multi-Agent Systems; Computational Tools.*

Introduction. Natural Sciences Informing Geo/Bio-Systemic Thinking

Advanced modes of study related to computation such as parametrics and simulation dynamics are often appointed in architecture to understand physical space through an all-systemic logic being similar to ones describing nature. Elements of the landscape, the ecosystem, the energy resources, the geo-political site and the socio-cultural context are cross-connected as systemic components with regards to their influences, performances and interrelated behaviors forming larger entities. Processes of analysis generally assume that the subject of focus is identified to its constituents, being recorded as data. Such a reduction of "concrete" reality to abstract manifestations of it happens through numeric, graphic and diagrammatic representations and is necessary so that complex phenomena become calculable and also that the elements making reality may be compared and assessed with regards to their mutual compromising and load-sharing. As this process is transferred to architecture, the models being created offer alternative formulas to examine intricate spatial conditions and to better integrate them with the existing fabric, effectively carried through to architecture's tectonic logic translated to order, structure, body and skin. New architectural and urban themes of natural reference may be generated as ways to relate with the urban milieu and to transform the code consistency of the human-made environment, offering novel solutions to problems often of no prior reference (Figure 1).

The analogy between architecture and nature was built around the early 1910s and since then it has outlined a topic of ongoing interest. Biologist Geddes (1915) studied the development of cities from a sociological point in analogy to biological processes.

Geddes elaborated specifically on the dynamic functions associated with

a-BaCO₃ filaments **c-BaCO₃ cubes** **t-BaCO₃ platelets**

o-BaCO₃: rods rod cross-sections rhombohedral rods 100 nm
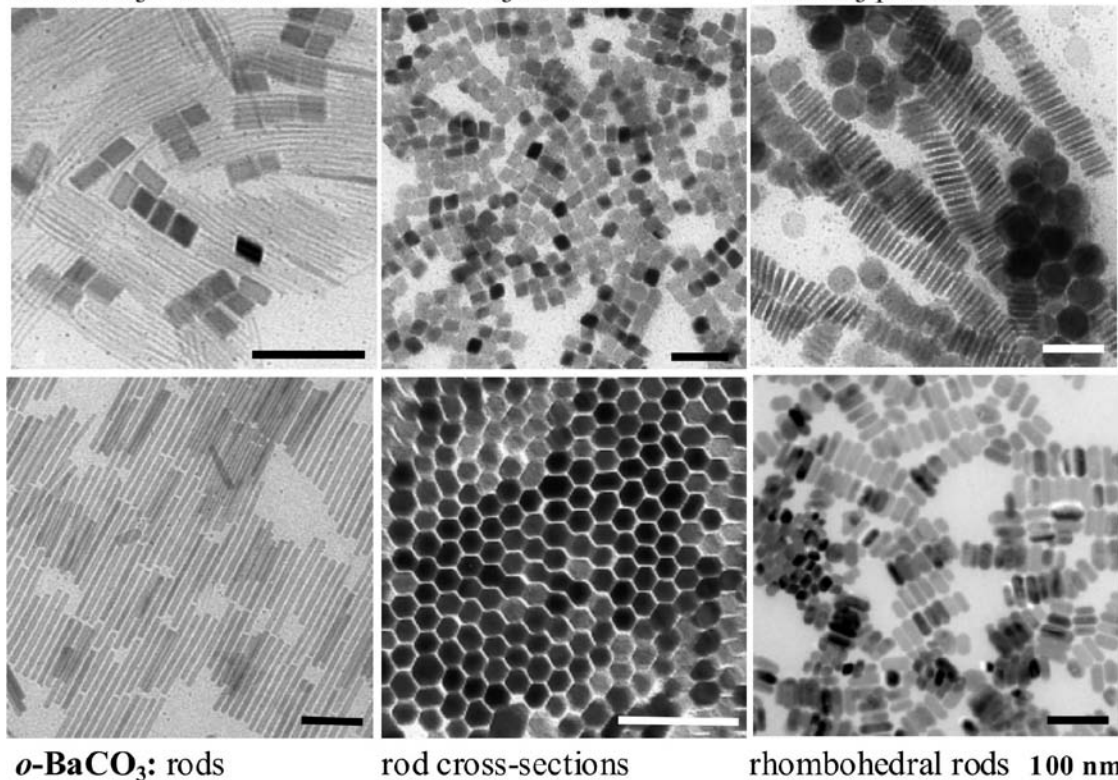
Figure 1.
Nanoscopic re-crystallisation patterns, nanoparticles in structural biology.

the initial formation and the evolution of human settlements. He further explored the interdependencies among organizational patterns, natural and environmental resources, capital flows, labor distribution and human needs found variously in every society. Another key figure was Doxiadis, who formed an extended interdisciplinary research group around the 1960s to study the affinities of human settlements with systems of biological origin. He came up with holistic models about the global ecosystem manifesting the analogies between cities and natural entities seen as organic totals in constant flux. In the 1960s and 1970s, Otto projected the analogy onto the processes of formation to propose tectonic approaches in architectural design, rather than ones relying solely on aesthetics. He employed form-finding techniques and performative operations to scrutinize structural efficiency (Drew, 1976), so that form would occur as the result of the dynamic relationships among forces such as gravity and material consistency. More original architectural expressions would emerge from within, that is, ones stemming directly from physical and environmental constraints and the broader earth system, rather than from established preconceptions. At the basis of such endeavors is the observation that architecture and nature may share that an element is conceived, analyzed through and lives along with its indissoluble connection with its greater environment. More than merely offering themes to imitate, this analogy has enriched architectural discourse with a rich asset of interdisciplinary references, techniques and tools assisting to readdress spatial conditions and their influences upon an architectural project.

With the advent of computing, operations related to dynamic simulation and scripting have contributed to frame the above analogy in more accurate terms. In the recent decades, research programs have been formed around this theme, which has been incorporated into the agendas and educational curricula of major institutions. The related groups have attempted to update the analogy from a rigorous scientific perspective (Frazer 1995) by utilizing reliable techniques for registering and manipulating information about design viewed as a system in constant energy flux. With digital tools approximating behaviors, phenomena and relationships even in real-time, it is possible to apply an all-encompassing approach about architectural design described as a performative process (Hensel and Menges, 2007). The related actions assume producing models that are suitable for testing ideas during design's intermediate steps until final resolution. Extensive data analysis, processing and recursive experimentation are main (pseudo-)scientific applications directed to produce form. Parametric tools have been used to break down a problem into systemic variables described by their dynamic properties in preparation for interaction. Computation assists in managing a set of agents acting as self-organizing principles during morphogenesis (Weinstock, 2004). In effect, it has been possible to construct the whole set of influences into dynamic models and so to emphasize on architecture's systemic character.

Multi-Agent Systemic Thinking as An Alternative to Aesthetics

Systemic thinking is commonly employed into design to explore the influences of extended data inputs. Initially developed in the 1960s with reference to Cybernetics (Pask, 1969), the underpinning idea has been to describe a design problem by autonomous agents interacting with each other forming larger systemic entities. Same as in nature, elements of an artificial setting do not function in isolation, but rather as parts of the broader environment they belong to. Agents are employed to pursue goals and carry out tasks and in general the resulting outputs may be supplementary as well as conflicting to each other. Multi-agent logic has helped to understand, manage, and use distributed, large-scale, dynamic, open, and heterogeneous computing and information systems (Weiss, 1999), which are rendered more resilient, robust and reliable in managing the sum of variables towards desirable aims.

A tentative list of design agents may include contextual factors as traits making the architectural system. These may be about the site, proximities and surroundings, energy, movement, connections and traffic with entry points, regulations, restrictions, enduring and changing conditions, social facts, economy, culture, existing and proposed activities, functions and the program (Ballantyne, Kawiti and Schnabel, 2016) (Figure 2). The agents are introduced as data sets and rules to express behaviors, properties, intensity and impact as ways to outline relationships to be carried out by the proposed scheme. Design is viewed as the result of complex relationships between these agents and moreover there is direct connection between the inputs and the form that occurs and vice versa.
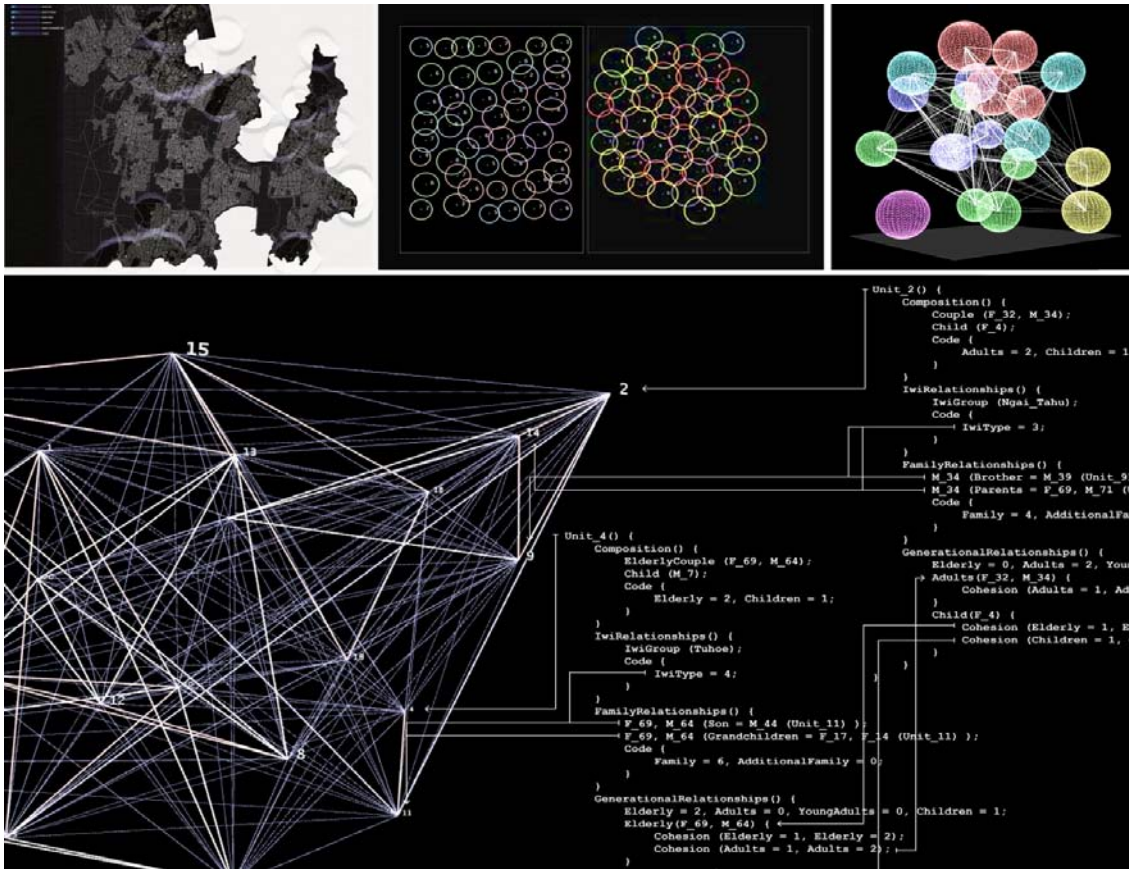
Figure 2.
Simulations of socio-cultural behaviors as systemic agents forming relationship structures (Ballantyne, A., Kawiti, D. and Schnabel, M.A., Urban Papakainga: Programming Cultural Criteria, by using Multi-Agent Systems, 2016).

Multi-agent applications reveal new potential about design outside its conventional aesthetic framing. For example, in answering the design brief, it is common to analyze information to a series of data inputs. In a traditional approach, most often it has been beyond the designer's control to measure and to manipulate the influences often acting in uncontrolled ways and so the result would mostly rely on intuition. Additionally, relating initial data inputs to each other through a system suggests more controlled ways to approximate their effect. A design problem is addressed through systemic data analysis and pursued through engineered responses. A design proposition becomes the result of iterative testing and progressive assessment as opposed to subjective judgment. Additionally, with software being currently available, data inputs may be studied together to produce results then referring back to the initial data. Ideally, an output scheme may refer back to the inputs and so it is possible to better control the effect of data upon the project. In effect, agent-based approaches have prompted to describe a design problem in scientific terms and employ methods of much higher reliability.

In extending the above, advanced computational methods related to dynamic simulation and real-time testing are employed to study "amorphous" situations of the urban context. A problem of architectural nature is approached through multi-agent logic; then, the produced data are processed to offer alternative design schemes.

From Amorphous to Re-morphing. Process of Spatial Transforming

"Amorphous," meaning without form or shape, may describe systems being inert due to causes such as high entropy, decay and death. In geology, amorphous refers to solid and liquid elements lacking long-range order being characteristic of crystalline structures, due to the fact that atoms and molecules are not organized in definite lattice patterns. It is attributed to residues, magma, or pulp of high viscosity and dormant matter, being the result of destructive processes such as deterioration, oxidation, erosion, sedimentation, solubility, dissolution, dissipation, decomposition and disintegration. From a chemical point, it refers to non-crystalline materials such as glass, gel and plastic. In biology, amorphous may be projected onto irregular, vague, anomalous, or undefined shapes and structures, also onto ones without a clear purpose.

Through processes of re-morphing, amorphous may turn to re-crystallization, new consistencies and new species. Related natural phenomena include diagenesis, metamorphism and other geo/biogenetic processes such as dislocation, lithification, dolomitisation, liquefaction, porosity, alteration, transformation and mutation. Re-morphing reduces a system's entropy. It refers to mechanical (macroscopic, extensive traits) and chemical (micro/nanoscopic, molecular, intensive properties, inner code) processes enacted by forces, temperatures, pressures and environmental constraints, leading to the genesis of new order, materials and features. Energy releases and other external factors act as dynamic agents affecting consistency, DNA, structure and form towards more active behavior, interaction with the surroundings and overall resilience.

An analogy is suggested between re-morphing processes of nature with those being about spatial transformation. Re-morphing in an urban or architectural context may talk about new interactions with the environment at macro (urban, permanent, long-term) and micro/nano (local, architectural, ephemeral) scale. The purpose of spatial re-morphing would be to introduce scientific ways of analysis leading to synthesis, along with the employment of dynamic tools and techniques as means to express and to simulate the influences of design traditionally managed by way of intuition, this present time in more consistent manners. Accordingly, re-morphing may assist behavioral, interactive and performative operations during the initial phases of design directed to data gathering, analysis, processing and form-finding. Given its affinity to science as outlined above, re-morphing may cause new architectural terminology with notions and concepts of bio/geological origin. These notions may be more suitable in explaining space's dynamic character, as they may be applicable across various scales, too. In effect, spatial re-morphing explains the urban setting as a highly sophisticated phenomenon, informed by energy exchanges and feedback among the participating agents of the local and the greater context.

Setting the Problem and the Methodology

The following study is framed within the context of the master's design core architecture studio entitled as "Re-morphing the Amorphous: Creating New Urban Substance," coordinated by the author at The University of Newcastle, Australia, in 2016. Analysis starts with a theme of natural origin carrying amorphous' main

characteristics. Selected themes have included lightning structures and the footprint effect they leave as they fall onto different material such as glass, sand and timber for project 1 (Figure 3); processes of sedimentation and residue development supported by web structures for project 2 (Figure 4); material dynamics with reference to the geological movement between solid ground and water flow for project 3 (Figure 5); symbiotic relationships and growing patterns of corals as ways these interact with their natural setting for project 4 (Figure 6) and; additive processes being reminiscent of wasps' nests for project 5 (Figure 7). The theme being selected is broken down to its constituents and the rules setting the relationships between them, then modeled through analogue and digital techniques; a method that refers to reverse engineering, whereby a fixed entity is analyzed to its parts through data gathering and series of abstractions further tested, explained and compared to each other. An intention to reorganize the parts prompts towards new strategies described as Design Research Hypothesis.
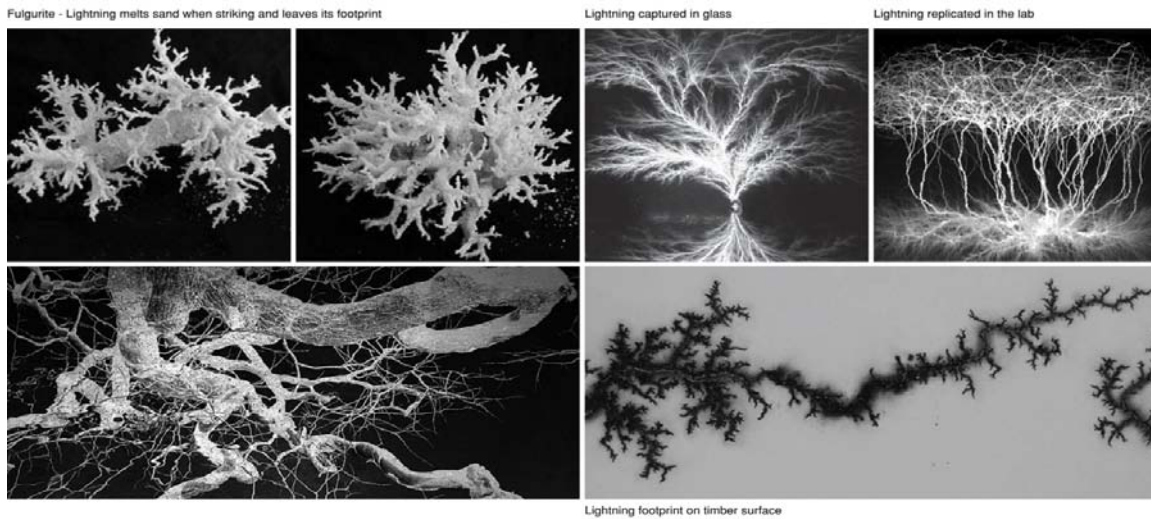
Figure 3.
Project 1: Lightning footprints on different materials (Tri-Nghia Phan, N., Re-morphing the Amorphous, 2016).
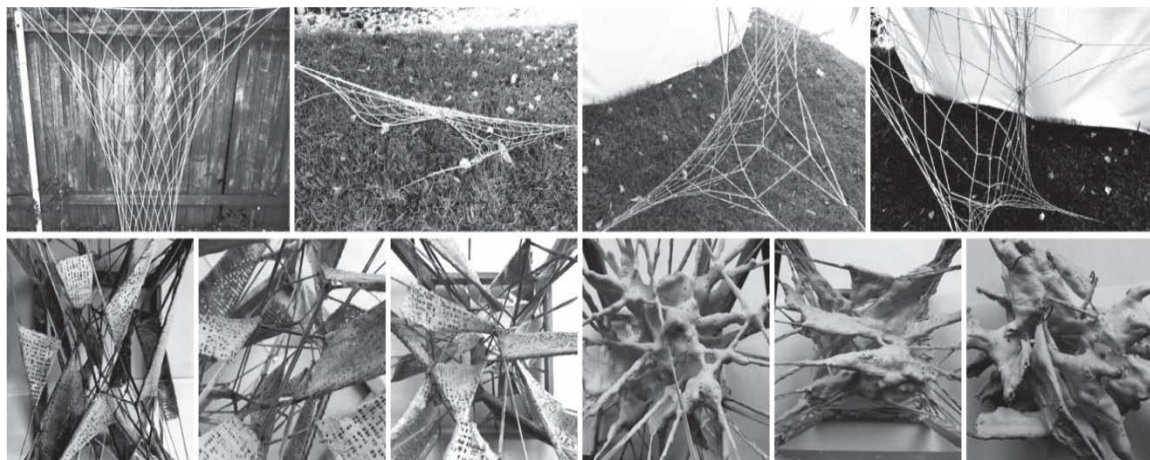
Figure 4.
Project 2: Model testing of residual formations supported by web structures (Sparks, K., Re-morphing the Amorphous, 2016).
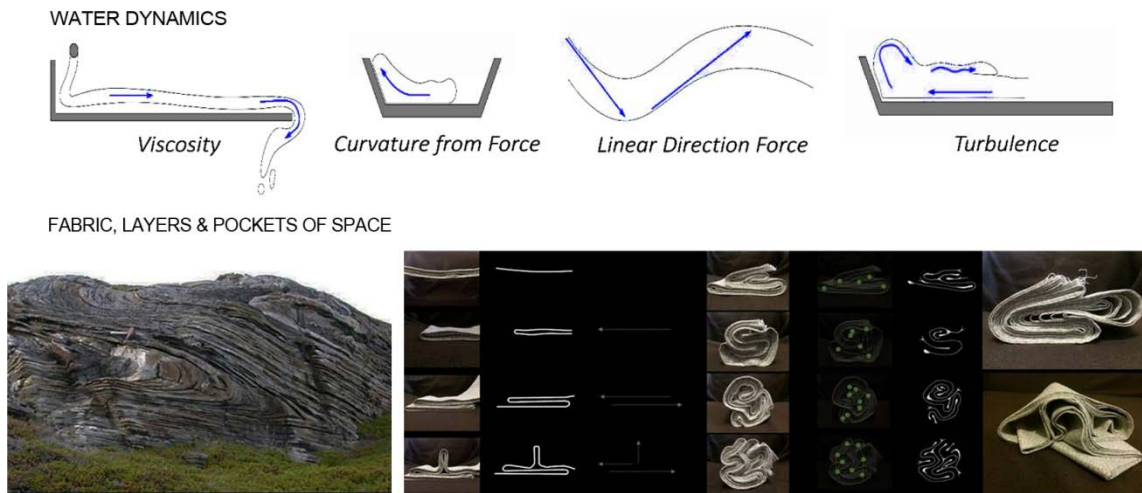
Figure 5.
Project 3: Geological forces of water and rocks creating space pockets (Alley, A., Re-morphing the Amorphous, 2016).

Figure 6.
Project 4: Red Coral structure remodeling (Reyes Castillo, N.A., Re-morphing the Amorphous, 2016).
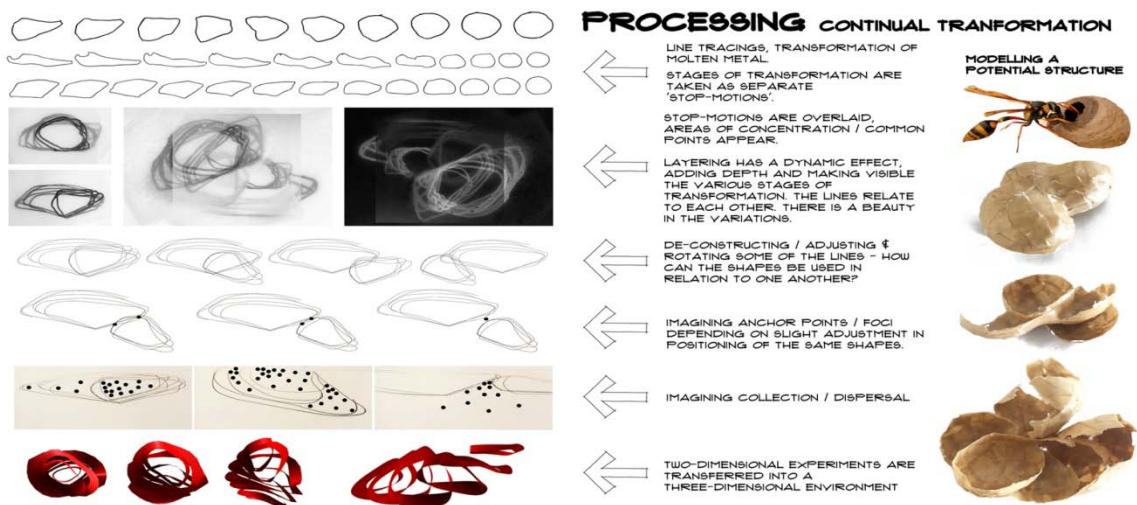
Figure 7.
Project 5: Additive processing reminiscent of wasps' nests (Johnstone, J., Re-morphing the Amorphous, 2016).

In the next phase, Hypothesis is related to amorphous-like situations of the urban fabric. Sites being in a state of dormancy are being proposed, offering semantic analogies with the scientific amorphous. An Argument is crafted by bringing together the Design Research Hypothesis with the site. The design problem is described by a set of agents interacting with generic geometric references via form-finding processes to produce alternative schemes. These agents refer to activities, site conditions, proximities and other local parameters acting as generative forces. Dynamic simulation, animation and other advanced modeling techniques are directed towards some kind of re-morphing, gradually adding architectural significance to the project. Related themes are: linear ruptures created by interacting with the urban setting to create 3D meshes that reconnect parts of the city (project 1); void fill-in strategies activated by traces of events currently occupying the walls, which form the boundary of the site and a layered history of its use (project 2); fabric, layers and space pockets created as a result of natural forces set upon geological materials of different consistency (project 3); dynamic expansion of a network structure at varying concentrations supporting the symbiotic relationship between public and private through activities related to surrounding buildings (project 4), and; tectonic strategies responding to unregistered events happening within the site area through unique components and dynamic mesh mold techniques (project 5).

The final step is to further adapt re-morphing to a selected site by producing new substance as architectural traits, living conditions, activities and relationships with the urban setting. Following the analogy with nature, a design scheme becomes a sort of re-crystallization, progressing through recursive testing through interactions with urban influences. The study concludes by demonstrating an overview of the design's focal points and the paths being pursued. Prototype models assist to examine the general logic with regards to onsite placement and fabrication solutions. It has been decided that projects of high relevance merge together forming larger group projects and so the final results are enriched with more references and have been developed to prototypes, with higher consideration of material choices and in a few cases construction techniques at physical scale. Projects 1 and 2 have been combined to a study about kinetic definition of surface interacting with adjacent activities to provide shading, protection and seating, as a way to activate temporary and permanent vacant lots (Figure 8). Projects 3 and 4 have offered an inflatable 3-dimensional layer above the ground, placed at urban squares and voids. Porosity patterns at varying sizes propose alternative ways of occupation and a symbiotic relationship between people groups and the urban setting (Figure 9). Project 5 has ended to a support structure made of paper and other recycled materials, set to "re-charge" underused squares and parks in proximity with existing buildings (Figure 10).

These design projects were driven by an experimental attitude. The participants were guided to form and test hypothesis in the aim of a systemic view linked to natural processes that responds dynamically to forces irrespective of traditional typologies. References of natural origin were selected and analyzed to their formative causes, then adapted to the urban setting. The results draw upon amorphous situations of the city. They challenge established notions about urban intervention by departing from the conventional architectural toolset to merge with scientific framing.

Figure 8.

Projects 1 & 2 combined: Kinetic definition of surface interacting with adjacent activities as a way to activate vacant lots (Tri-Nghia Phan, N.,Sparks, K., Re-morphing the Amorphous, 2016).

Figure 9.

Projects 3 & 4 combined: Inflatable layer above the ground offers alternative ways to occupy the urban setting. Prototype structure adapted and fabricated at natural size at the studio space (Alley, A., De Belle, B., Reyes Castillo, N.A., Triantafyllou, C., Re-morphing the Amorphous, 2016).

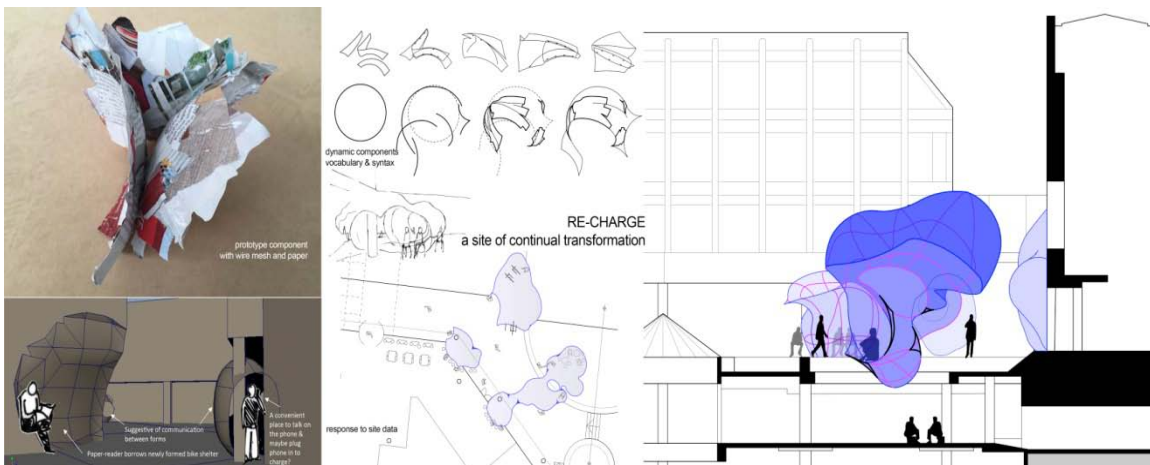

Figure 10.

Project 5: Structure made of unique components, set to "re-charge" underused parks in proximity with existing buildings (Johnstone, J., Re-morphing the Amorphous, 2016).

Conclusion

This paper's main scope has been to suggest systemic approaches in architectural design by employing a variety of computational tools and dynamic processes deriving from the scientific framing. The design study being presented has drawn upon nature as an asset of references related to multi-agent systemic thinking, then adapted into architecture. There are many analogies between the built environment and natural phenomena, prompting to approach a design problem of any kind via systemic logic. With the advent of computation, it has been possible to expand on the analogies between architecture and nature beyond mere transference of aesthetic themes to describe behavioral properties. Advanced techniques such as dynamic simulation, scripting and extended modeling have assisted to respond to a wide range of scenarios assuming the architectural edifice to be a part of the broader ecology, aiming to re-establish architecture's links with its socio-environmental framing.

The above view has outlined the strategy to respond to design problems of the urban setting. The presented works offer alternative ways to reactivate parts of the existing fabric lying dormant for long, hence described as "amorphous," through some kind or "re-morphing." Analysis of natural phenomena has helped to understand the dynamic operations performed in multi-agent systems, as well as to propose a vocabulary then appropriated into architecture. Related processes have been applied to represent architectural data through agents describing the urban context dynamically affecting solutions. As such, these inputs have been activated to construct the first design schemes, then being refined into propositions and fabricated prototypes. The outcomes have introduced new typologies, shape characteristics, spatial conditions and building techniques as new urban substance.

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