HAL
open science

The Impact of Nature Inspired Algorithms on Biomimetic Architecture and Urban Design

Natasha Chayaamor-Heil

To cite this version:

Natasha Chayaamor-Heil. The Impact of Nature Inspired Algorithms on Biomimetic Architecture and Urban Design. Conference on Biomimetic and Biohybrid Systems, Living Machines 2018, Jul 2018, Paris, France. hal-02544328

HAL Id: hal-02544328

https://hal.science/hal-02544328v1

Submitted on 16 Apr 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

The Impact of Nature Inspired Algorithms on Biomimetic Architecture and Urban Design

Natasha Chayaamor-Heil

MAP-Maacc, CNRS-MCC UMR 3495, ENSAPLV, France

Abstract: At the time when the value of architecture no longer results from creating shapes in space, but rather fostering relationships within it. A concept of architectural design becomes a strategic process rather than an object. Biological inspiration is dominating the era, and has its impact in diverse domains, including architecture and urbanism. The study of biomimetics bridges the biological functions, processes and organizational principles found in nature with our designs and technologies. Recently there are numerous mathematical algorithms have been developed along with the knowledge transferring process from the life forms to solve the design problems. Output of biomimetics study includes not only physical applications, but also various computation methods that can be applied in different areas. We can learn from biological processes and principles to design and develop a number of different kinds of optimization algorithms that have been widely used in both theoretical study and practical applications. In this paper, we discuss and present the impact of nature inspired algorithms and digital advanced on biomimetic approach in architectural and urban design. We demonstrate how architects reuse bio-inspired computing to solve complex problem or optimize their designs, and nonetheless, how architects use algorithmic architecture software to directly transpose the complexity of nature's principles into their design process.

Keywords: Biomimetics, Biological process, Nature inspired algorithms, Architectural and Urban design.

Introduction

Nature has always been an inspirational source for architects and designers. This inspiration has given highly efficient designs in various fields. One of the best concept in which, we see nature as the influential source of inspiration. Biomimetics means imitating of biological processes. Biomimetics is a new science and design discipline that studies nature's models and then emulates these forms, processes, systems and strategies to solve the problems of our time [1]. Undoubtedly, architects have been inspired by nature to stimulate a novelty in their designs, but beyond the appearance of a tree, a branch or a simple leaf, there are mathematical patterns at play in nature. Understanding nature's basic algorithms allows architects and designers to explore natural systems that can be translated into efficient designs and awe-inspiring architecture.

Biomimetic Methodology

Biomimetic architecture is a contemporary approach of architecture that seeks innovative and sustainable solutions in nature, without attempting to replicate its forms, but by seeking to understand the rules that govern them. The objective of biomimetic architecture no longer consists solely in giving form and measurement to space but also in developing synergistic relationships between the construct and its environment. The heuristic approach to biomimetics consists in bringing architecture to '*vitalism*' beyond the mechanistic view of life.

Interdisciplinary collaboration is necessarily essential in biomimetic design process where the knowledge from different fields converges, which leads to innovation and increase the novelty of design ideas. However it must also be understood that as these design processes requires the collaboration between the architect and the biologist, a similar collaboration might be required between an architect and a computer programmer or mathematician to create the complex algorithms that are used in nature. As the architect though can create the concept and workflow may not be skilled enough in making the algorithm.

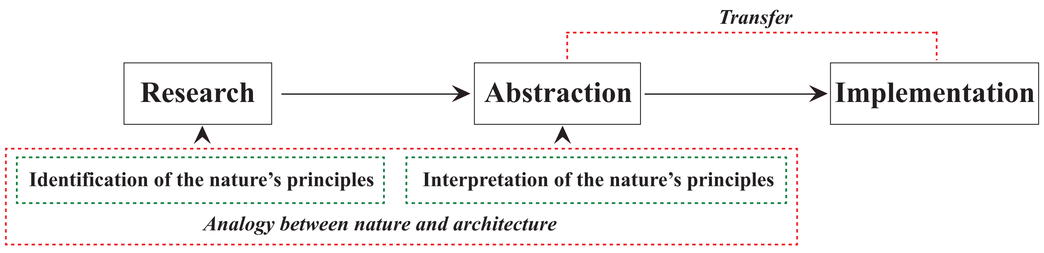

Fig. 1. The two transitions of a cognitive biomimetic design process within the context of an interdisciplinary, adapt from [2]

In view of these two transitions, it is possible to distinguish two postures of the use of biomimetic approach in architecture: an indirect posture where the architects explore biologically inspired computing as a tool derived from biomimetic interdisciplinary collaboration between biologists and computer scientists, and a direct posture where the architect integrates directly an interdisciplinary biomimetic activity and use computational algorithms to transpose biological knowledge in its architectural design process.

An indirect biomimetic methodology in architectural design activity

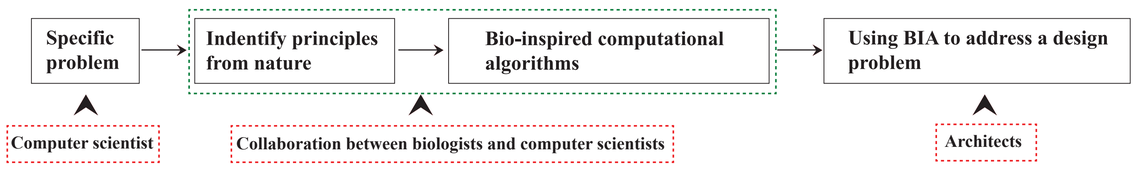

Fig. 2. The following figure describes a possible architectural design process resulting from collaboration between biologists, computer scientists and architects.

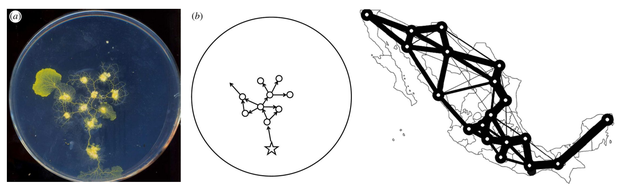

Fig. 3. (Left) The behavior of the Physarum Polycephal observed in a petri dish and the bio-inspired mathematical model of the exploratory behavior of Physarum Polycephal [3], (Right) the transportation network in Mexico City developed by the Physarum Solver [4]

The following case study presents the use of a biomimetic algorithm capable of designing an optimized transport network between different cities while taking into account a certain number of characteristics (population, points of interest, possible breakdowns on the network, etc.). Based on the observations and mimicking the behavior of a slim mold called *Physarum Polycephal*, the algorithm *Physarum Solver* was constructed. This algorithm is able to find an optimal path in a network and proves to be more efficient than the classical algorithms when the number of nodes of the network is very important.

A direct biomimetic methodology in architectural design activity

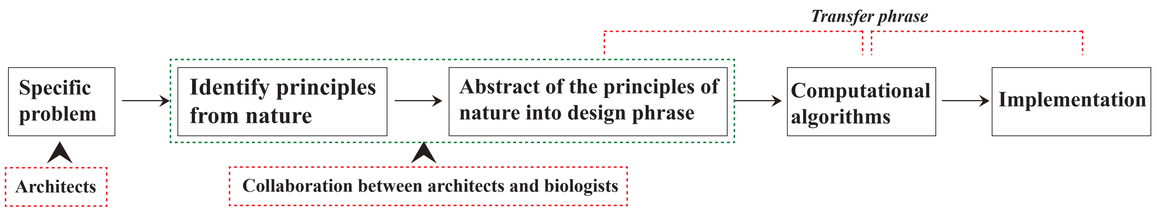

Fig. 4. The following figure describes a possible architectural design process resulting from direct collaboration between architects and biologists and the use of computational algorithms to transpose nature's principles into design phase.

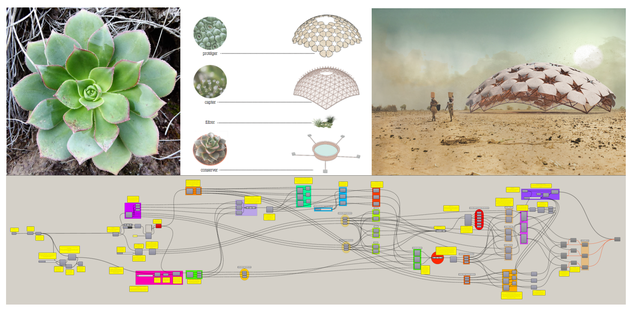

Fig. 5. (From top left to right) The succulent plant *Aeonium percarneum*, the functionality of the fog sensor dome, the rendering of the dome prototype, (Below) The Grasshopper canvas of the AEONIUM design process [5]

This architectural project 'AEONIUM' proposes a fog sensor built near a typical rural village of Burkina Fuso. The operation of the dome is inspired by the metabolism of *Xenophile* plants (for example, succulents) and their different strategies developed to capture and store the water contained in the ambient air. The project was entirely realized with the help of an algorithmic software Grasshopper [6] and algorithmic families (fractals, AC, AG, complexity, etc.) while adopting a biomimetic approach. The architects have made an analogy between the principles of the plant and the design concept and once the biological principles are understood as a design task, the architect transcript them in Grasshopper.

Conclusion

This paper is an investigation into the development of design method based on biological principles that are applied and correlated with nature inspired algorithm and computational design in the field of architecture. It can be concluded that the stated methodological frameworks enable the designer to produce an efficient architecture in terms of optimization and innovation. But at the same time this approach relies on very specific knowledge, skills and tools. Without computers these complex ways and forms of structures couldn't been mimicked and thus using computers had risen the way of mimicking and taking inspiration from nature because it is considered a very sophisticated and accurate tool for simulation and computing, as a result designers can imitate different nature's models in spite of its complexity. Thus biomimetic designs can be produced that achieve structural and environmental performances that were once considered to be post-design optimization processes.

Bibliography

1. Chayaamor-Heil, N., Guéna, F., Hannachi-Belkadi, N., Biomimicry in Architecture: State, methods and tools, Les Cahiers de la recherche Architecturale Urbaine et Paysagère, http://journals.openedition.org/craup/, (2018).
2. Nachtigall, W., Bionik als Wissenschaft: Erkennen-Abstrahieren-Umsetzen, Berlin, Springer/Auflage, (2010).
3. Adamatzky,A.:Slimemouldprocessors,logicgatesandsensors.Philos.Trans.R.Soc.Math. Phys. Eng. Sci. 373(2046) (2005).
4. Mahadevan, S.: A biologically inspired network design model. Sci. Rep. 5, 10794 (2015).
5. AEONIUM. https://aeonium.wixsite.com/project.
6. Grasshopper:AlgorithmicmodelingforRhino.http://www.grasshopper3d.com.

Acknowledgements. This article is part of an extended research of Biomimicry in Architecture: State, methods and tools, which is published in les Cahiers la recherche architecturale, urbaine et paysagère, issue Innover 2018.

printed by MegaPrint Inc. www.postersession.com