Chapter 13
Optimization and Evolution in Architectural Morphogenesis: Evolutionary Principles Applied to Mass Housing

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ABSTRACT
In the last century, a large number of architects and engineers developed a variety of form-finding strategies, and some of them looked to natural systems with the aim of transferring their principles into architecture. Through digital techniques, the designer can emulate or invent new processes to create architectural forms characterized by the same efficiency and beauty of natural systems. In particular, the efficiency of living systems is the result of a slow evolutionary process, as explained by Darwin’s theory of evolution. The possibility to apply this process to architecture through genetic algorithms puts in the hands of the designer a powerful tool, which can be used in a wide variety of applications. In this chapter, by means of a case study, a form-finding strategy based on genetic algorithms is structured. A generative model able to adapt to different contexts is designed, and the research of the final shape is driven by a multifunctional optimization process aiming to reduce the energy consumption of the building and the weight of its structure.

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INTRODUCTION

The historical relationship that exists, since their origins, between Nature and Architecture, has characterized and influenced, in different ways, all architectural styles. Central to this subject is not the mere mimesis of the form, but rather as Heidegger stated, the understanding of nature “as an organized set of computable forces” (Heidegger, 1986). Technological developments give new impetus to this field of research providing new techniques to analyze form and morphogenesis.

“Nature offers not forms but processes to think about form” (Neri Oxmann, 2010) and it is in this sense that architectural and digital morphogenesis became central for contemporary designers. With the windward of digital representation, the algorithm becomes a tool to configure new processes. The algorithm of the line (Rubertis, 1994), which is at the foundation of canonical representation, in the digital realm is replaced by an algorithm that, in principle, can construct “any conceivable network of relations between a given set of element attributes” (Schumacher, 2011).

The vision proposed reveals an interpretation of the contemporary architectural thought, that is gradually moving away from the typological classification of the Modern by looking at self-formation processes in nature (Tedeschi, 2014). Architecture, like Nature, is a network of relationship encompassing countless data and interrelations. In most cases, the level of complexity shown by contemporary architecture is larger than the ability of designers to understand and predict them. However, by the use of digital design tools, the designer can effectively handle heterogeneous information and complex associative rules.

Starting from the 1990’s shift has been noticed in the way avant-garde architects have used new technologies of evolutionary biology to address or depict the increased complexity that is noticed in today’s architecture (Fausolaki, 2007). “Adaptive capacity or adaptation is a key ambition of the contemporary avant-garde trend that might suggest a comparison with natural organic systems. (Schumacher, 2006)

As theorized by Charles Darwin, the evolutionary process, despite the complexity and efficiency that generates in living systems, is simple enough to be translated into an algorithm. Since, in the late 60’s, Ingo Rechenberg and his colleagues applied for the first time the Genetic Algorithms to aerodynamic wing design (Rechenberg, 1973), several designers mainly in the field of engineering started to use these powerful fitness-based tools to solve complex design problems.

This research deepens the possibility to design, through generative systems and evolutionary principles, an architectural model able to adapt to different contexts and conditions, providing different solutions as the result of the interaction with the surrounding environment. In this sense, crucial is the idea to design rather a unique architectural solution, a generative model, characterized by diversity and adaptation.

This approach to design is made possible only by a new industrial model based on modern Computer Aided Manufacturing techniques. Indeed while generative systems allow the designer to visualize thousands of design options, the assembly line allows creating thousand of variations of the same product. Developing a direct link between what can be designed, and what can be built, it is possible to go beyond the limitations imposed by mass-production, reaching, like in automobile and aeronautics industries, a design-driven manufacture process that provides the designer with a high degree of freedom.