SPECULATIVE EVOLUTION: COMPUTATIONAL AND BIOGENETIC ANALOGUES IN CONTEMPORARY ARCHITECTURAL PRODUCTION

PASQUALE DE PAOLA
Louisiana Tech University

> "An abstract machine in itself, any more than it is semiotic; it is diagrammatic (it knows nothing about of the distinction between the artificial an the natural either). It operates by matter, not by substance; by function, not by form." - Gilles Deleuze and Felix Guattari[1]
>
> "All knowledge, as issuing from reflection, is experimental." – John Dewey[2]

INTRODUCTION

The discipline of architecture is invigorated continually by new modalities of both representation and production. Certainly, the latest developments in computational design and digital technologies have dramatically increased architecture's repertoire of forms. Yet, the redundancy of most systems of architectural production—especially those that promote repetitive seriality and disengage with local ecosystems—today require new modes of interdisciplinary research that engage in speculative and inventive modes of design and production.

This paper does not intend to be another manifesto aimed at fetishizing bio-analogue formalism that results in incoherent and impractical designs. Instead, I point out that through certain computational strategies and the development of precise generative algorithms that optimize variance, we can establish a new material praxis more responsive to climatic and ecological issues, and also more open to optimal procedural variance. Standardization as we know it is no longer necessary.

While modularization and mass-production historically defined the technical and tectonic developments of modernist architecture—as dictated by a utilitarian imperative to produce quantity rather than quality, and by promoting a consequent arbitrary sameness—its lingering theory had produced an architecture dictated by a limited functional approach wherein different practical inputs were forced to conform to rigid industrially produced outputs. In other word, architects became hostages of this approach in which the necessity to produce quantity rather than quality had lead to the consequent lack of morphogenetic differentiation, leaving free ground to a rigid functionalist approach in which different methodological inputs had produced the same formal and material outputs. Fundamentally, such a methodology of repetition had created a rather inadequate repertoire of processes and fabrication methods extremely attached to those pre-industrial models of production that sought in standardization a way to discipline the making of things.[3]

To avoid this cumbersome redundancy and promote procedural evolution, any assumed modalities of modular processes must be critically reframed by generating a new methodology prescribed by complex computational systems based on biological analogues and evolutionary solvers/algorithms.[4] Ideally, any new system would selectively create innovative modes of architectural morphogenesis and material production, which, through data-collection and cybernetically controlled analysis, might fit better within certain scenarios.

However, success should not be defined by formal aesthetics alone; instead, any measure of success should focus first on issues such as physical embodiments of performance factors, evolutionary adaptation, systemic intelligence, and behavioral autonomy. A key measure of any biogenetic system applied to architecture would be long-term survival in constantly changing urban environments and responsiveness to unpredictable climatic conditions.

THEORETICAL UNDERPINNING

The theoretical speculation behind this paper generates from the idea that architectural form, and its material expression, emerges from the machinic assemblage of energy and matter.[5] Within this context, biological and material processes are quantitatively equated through mathematical and operational tendencies, which determine patterns of growth and morphogenetic variance. In Particular, this points to a much deeper understanding of biogenetic methodological analogues, which can be differentiated by a Deleuze-derived diagrammatic methodology of multiplicity. To fully unpack this relationship between biogenetics and architecture, we need to revise our traditional means of architectural production, reset its material expression, and recondition methodologies of construction in order to generate architectural solutions that fit complex assemblies and networked systems.

In this paper, I examine the use of new models of architectural production operating through specific computational tools such as Grasshopper, Galapagos, and Generative Components. Those parametric-associative platforms can simulate genetic growth as well as the evolution of construction processes algorithmically. In these cases, the tool's existence and development has outstripped the pace at which theory has attempted to explain its innate possibilities. Most of this theoretical framework is underlined by diagrammatic modes that deterritorialize the meaning of architectural production in order to open it up to new functions and processes. The Deluzian abstract machine reappears in the form of algorithmic computational design procedure that destratifies traditional architectural production through parametric manipulation of preset numerical data sets. Interestingly, this strategy produces a multiplicity of distinctive procedural and morphogenetic differentiations while operating by matter, not substance, by function, not form.[6]

As contemporary architecture becomes increasingly dependent on the overwhelming digitalization of architectural production, we must avoid returning to functionalistic approaches based on preset of inputs and standardized outputs that create stagnant repetition. My main argument shows that computational design strategies can not only facilitate processes of differentiation and respond palpably to data inputs, but they can also implement an approach where genomic variations and protocellular source code can algorithmically generate and manipulate material digitally. But before addressing this dynamic methodology of variation, I must address historic modalities of architectural production that date back to the beginning of the 20th Century. By outlining this period in architectural history, we can better understand how standardization has damaged the creative and performative aspects of architectural production by relying too much on a repetitive and inflexible framework.

EARLY MODALITIES OF ARCHITECTURAL PRODUCTION

> "Considering each national scene as a porous rather than closed realm reveals systems of domination of varying types, intensity, and duration, from industrial modes of production to patterns of leisure… Long before the advent of air travel and new information technologies, the global circulation of ideas and images by way of steamship, the telegraph, and the mechanical reproduction of pictures – all nineteenth-century invention – shaped every local scene." - Jean-Louis Cohen[7]

The history of architectural modernity has been characterized by cultural, territorial and technological transformations. All together, those changes have indeed generated a new aesthetic predominantly dictated by new materials and new modes of architectural production.[8] The use of steel, glass and reinforced concrete integrated rapidly into the lexicon of design and construction—improving their stability, functionality, and, in some cases, their aesthetic sensibility. As indicated by Kenneth Frampton, the use of cast iron columns, wrought iron rails, and modular glass panels had become the main mode of production, typically because of its capacity to provide a standardized framework rather easy to assemble and also extremely functional according to the programmatic premises of early modernism.[9]

In addition, if we consider the socio-political situation of early 20th Century, characterized by a nationalistic ambition typical of the Romantic time, and the imperialistic will to become a well-established and dominant nation state, it is easy to understand why countries such as Germany, France, and England chose to focus on a capitalistic economical systems based on industrial mass-production that prioritized quantitative serialization over objective quality.

Manfredo Tafuri primarily addressed this modality typical of the Enlightenment, in his seminal work, *Architecture and Utopia*, in which he stated that the production of architecture had always turned to the authority of capital accumulation, creating a strong separation between architecture itself and its modes of production. Consequently, cities had become the built expression of such a dichotomous representation, where naturalistic models, based on a humanist and picturesque approach as suggested by Marc-Antoine Laugier, are replaced by functionalist models characterized by modularization of production, heteronomy of form and social segregation. Simply put, we transitioned from a model that embraced nature to an antithetical model where nature was exploited to produce raw resources utilized in industrial production.[10]

Interestingly enough, the same modalities of architectural production, based on the idea of quantity (standard) above quality (non-standard), became the driving factor behind early 20th Century design praxis. I am referring here to the functionalist agenda of CIAM IV in 1933, whose well wishing policies and best intentions ended up backfiring, creating a design culture that sought the use of modular processes of architectural production as a way to increase financial retribution while avoiding social reform. Essentially, and following a proposition established by the leftist group ABC that included among all Dutch architect Mart Stam, and Swiss architects, Hans Schmidt and Hannes Meyer, the machine metaphor had proposed an architecture where the homogeneity and repetitive seriality of building components would lead ultimately, in the lower echelons of architectural production, to sterile and generic buildings lacking in morphogenetic variation. This approach generated a naïve and generic catalog of standardized solutions that, along with other processes of design and ill-conceived notions of social engineering, led eventually to the death of modern architecture announced famously by Charles Jencks as happening on March 16, 1972.

> "That many people did not notice, and no one was seen to mourn, does not make the sudden extinction any less of a fact, and that many designers are still trying to administer the kiss of life does not mean that it has been miraculously resurrected. No it expired finally and completely in 1972…"[11]

Clearly, the modernist architectural production had been damaged by a quasi positivist methodology that had denied any sort of morphogenetic variation, since it stood for mass-production of similar outcomes. It has to be said that Manfredo Tafuri, prophetically, had already anticipated this negative scenario while reading Walter Benjamin's *The Work of Art in the Age of Mechanical Reproduction*. In fact, Tafuri stated that: "To ignore either the limitations of the possibilities of communication or the new horizons opened by the means available to architecture clearly leads to an evasive attitude."[12]

Thus, rather than reproducing exact copies of already seen buildings, the modernist agenda should have been more critical toward the processes of production. Collectively, architects should have addressed the questions of "when" and "how" criticality should have entered the production process. The process was linear in structure, too conditioned by an assembly-line mentality; not an evolutionary or cybernetic structure, and therefore embedded with recursive feedbacks that feed as inputs back into the system. The lack of an active and operative feedback system certainly delayed the possibilities for a more reactive design process.

ON MACHINIC ASSEMBLAGES

> "A machinic assemblage, through its diverse components, extracts its consistency by crossing ontological thresholds, non-linear thresholds of irreversibility, ontological and phylogenetic thresholds, creative thresholds of heterogenesis and autopoiesis. The notion of scale needs to be expanded to consider fractal symmetries in ontological terms." – Felix Guattari, Chaosmosis.[13]

My line of reasoning generates from the idea that architectural form and its material manifestation and expression ought to emerge from the "machinic assemblage" of energy and matter, which should be quantifiable through algorithmic aspects. What truly comprise a machinic assemblage? According to Gilles Deleuze and Felix Guattari, machinic assemblages designate morphogenetic processes that generate new structures while operating in total autonomy, and without any procedural hierarchical control.[14] The main premises of such a practice are found in the heterogeneity of those elements actively engaged in the process where sets of relationships among different systems generate the machinic premises. In this case, it is about deterritorializing, and decontextualizing those sets of relations that defines normative processes of material production.[15]

Manuel De Landa summarizes the same procedural ontology by referring to machinic assemblages as "meshworks," where both nodal relationships and hierarchical contingencies are in constant change and are never exposed to any regulative practice (rule of modality).[16] Meshworks contain a variety of elements, which, when meshed together, create a new complementary system characterized by biosynthetic archetypes that in fact display a higher level of integration between their self-organizing functionality and cellular materiality. What truly matters in this process is the intrinsic ability of the meshwork to operate by processes rather than form, and I believe this to be vital while analyzing issues of architectural and material production.

Form has to perform in the end. Yet, it is the process, which encodes performance that truly matters. The limitations imposed by the traditional way things have been produced so far have restrained the richness and effectiveness of our discipline. As explained above, the value of architectural production and its material form have to be generated according to the guidelines of machinic assemblages or meshworks where heterogeneity and diversity of construction can finally come together in a multi scalar and multi layered approach that allows for diversity to emerge.

EVOLUTIONARY COMPUTING

The increasing availability, development, and use of computers has significantly changed our understanding of architecture as a material practice. Traditional processes and materials can't cope with the technological demands of our growing urban ecosystems. Algorithms and evolutionary computing packages process a lot of data, and efficiently filter and select the more desirable outcomes, avoiding incompatibility and failures.

Parametric-associative platforms have the ability to facilitate and simulate evolution of construction processes based on algorithmically organized components. Most of this theoretical framework is underlined by diagrammatic modes that deterritorialize the meaning of architectural production in order to allow for more adaptable methods. In fact, this algorithmic process can also localize and transfer properties and processes involving simple materials systems into basic computational constructs to use their potential as generative logic and small-scale components in reality. Yet, we can transfer a material system into the digital realm only after a thorough observational process has been finalized. This involves an accurate study of material behaviors, conditions, dynamics, and structure—altogether, this thorough analysis is necessary in order to fully understand the emergence of certain material and procedural performances.

Most of the software solutions available (Grasshopper, Generative Components and Galapagos to name a few) can mimic evolutionary computing through the use of algorithmic definitions that consider issues of acquisition, utilization and allocation of resources available. This does not necessarily create an expected or predetermined form, but it generates an optimized model by way of finding satisfactory solutions. With this process, similar definitions/scripts (modularly is here established by the nature of the commands that we can run) can generate different outputs based on the differentiation of site-specific sliders/parameters. Like genetic encoding, the Deluzian machine reappears in the form of algorithmic procedure and evolutionary programming strategy that alter our traditional definition of architectural production by reintroducing the same computational algorithm into a new context. Eventually, this parametric operation that involves the manipulation of preset slider and numerical inputs ends up generating an unmistakable process of morphogenetic variations.

SOME EXAMPLES

This methodology of diversity through multi scalar approaches is not necessarily new territory, but it was theoretically explored in the early 60's and 70's by both Christopher Alexander and Yona Friedman.

In Notes on the Synthesis of Form, Christopher Alexander opens his introductive chapter by stating that:

> "These notes are about the process of design; the process of inventing physical things which display new physical order, organization, form, in response to function. Today functional problems are becoming less simple all the times."[17]

Interestingly enough, Alexander's book addressed a series of questions about the design process by proposing a modality based on the resolution of inherently articulated problems, in which the main apparatus had to be deconstructed into multiple diagrammatic models. Thus the broader problem, in its most general pattern, must be broken down into multiple sub diagrams in order to grasp the innate mechanisms from which we might derive a synthesis of form. Based on Alexander's work, it is clear that, as architecture is becoming more and more complex, architects are in need of better visual and mathematical diagrammatic structures (Figure 1) that can finally provide information about how specific systems or sub systems interact with each other. Alexander concludes that:

> "My main task has been to show that there is a deep and important underlying structural correspondence between the pattern of a problem and the process of designing a physical form which answers that problem. I believe that the great architect has in the past always been aware of the patterned similarity of problem and process, and that it is only the sense of this similarity of structure that ever led him to the design of greats forms."[18]

Figure 1. Optimal layout for an Indian Village. Image from, Christopher Alexander, *Notes on the Synthesis of Form*, (Cambridge, MA: Harvard University Press, 1964), 173.

Yona Friedman also uses a mathematical approach as a methodical design inquiry that seeks the development of a theory that would "free the client from the patronage of the architects."[19] In both cases, the generative quality of the design process underlines a scientific approach where a main operative system or pattern is first recognized and it is then broken down into multiple sub-systems that are described by a number of mathematico-logical statements (or preset numerical data sets).

In a geometric way, axioms are created from the linkage between subsystems, and are then verified through given algorithmic conditions established by the scientific framework itself. Interestingly enough, the work of Alexander and Friedman addressed the actualization of a positivist machinic assemblage before the machinic assemblage was theorized by both Deleuze and Guattari in 1980. However, Alexander and Friedman's research showed how architectural production indeed needed to face the problem of heterogeneity while providing multi-scalar solution that avoided crystallization of processes and consequent mechanization (and nonspecific reproducibility) of building form. Based on those operative agents of positivist inquiry, their work operated by matter and function, anticipating the birth of computational solvers and other parametric tools.

While looking at the contemporary production of those strategies that avoid redundancy while operating in a realm of heterogeneity, it is interesting to look at the design pedagogy implemented by both Michael Hensel of OCEAN, and Patrik Schumacher, partner at Zaha Hadid Architects and founding director of the AA Design Research Lab in London (DRL).

Both Hensel and Schumacher have endorsed the increasing use of computational technology and digital fabrication through a process that is generally dictated by the use of parametric interfaces such as Grasshopper, Galapagos, and Generative Components. Yet, it is also interesting to note that, while the last ten years have been characterized by the heavy development of digital tools, it is also becoming evident that it is now time to establish what Robert Aish calls "a culture of use of these tools;"[20] it is indeed time to start fully integrating those non-linear and cybernetic techniques to the design process in order to facilitate the production of alternative configurations both formally and materially.

In this regard, Michael Hensel, through the pedagogy implemented at the Architectural Association in London and at his collaborative practice OCEAN, has created an interesting research framework that conducts interdisciplinary and trandisciplinary research by design while looking at the feasibility of a performance oriented architecture established through biogenetic analogues. His work at the EmTech (Emergent Technologies Program at the AA in London) has particularly analyzed the use of generative learning algorithms, and how they might relate to the creation of the so called morpho-ecology (ME) approach, which involves a series of formal and structural explorations that are responsive to particular material and manufacturing systems. Most of the work there is not finalized to the production of new forms, but it is instead driven toward the assembly of adaptive systems that generate guidelines toward an understanding of material and structural identities embodied in the product designed. Form is essentially just one of the results achieved within this process of complexity.[21]

In Patrik Schumacher's case, research is aimed toward the understanding of the self-making of architecture, or what he calls the "autopoiesis" of the discipline.[22] Like Friedman and Alexander, Schumacher believes that in a world dictated by convolutions and complications, we are in need of a new theoretical systematization, which he recognize into the parametric condition of architecture. As Schumacher states,

Figure 2. Zaragoza Bridge Pavilion (Image courtesy of © Zaha Hadid and Patrik Schumacher).

> "The purpose of my theoretical work is to legitimately and confidently claim that it is time for new style, to change the physiognomy of the built environment like the modernism did in the twentieth century. We now have new generations of architects, new semiology and completely new tools. I have been working on it for more than fifteen years and in 2008 it occurred to me that it is definitely becoming a new paradigm, so I came up with the name parametricism. If we succeed, and I have no doubt that parametricism will succeed, we'll change the physiognomy of this planet."[23]

Again, we are becoming more and more aware that heterogeneity and complexity are disturbing the clarity of what architecture's new challenges are; yet, rather than discarding this framework of heterogeneity, Schumacher proposes the establishment of a complex apparatus that embodies form and materiality. Yet, if we look at the design production of Schumacher while testing his parametric principles (Figure 2), it is really hard to recognize a synchronized and complementary reconciliation between form and materials, while it appears that materials have been somehow forced into a particular formal scheme.[24]

CONCLUSIONS

Computational and biogenetic analogues demonstrably improve productivity and workflows.[25] Additionally, the algorithmic process that links multiple layers of components and parameters makes the alternatives we design rapidly adaptable and ready to be delivered and fabricated. Again, the use of parametric tools should not be seen as a way to create new formal exuberance, but instead it should be understood as accounting for multiple representations derived from a single system of decisions, which can be controlled though scripting—a process that concludes in an algorithmic synthesis of all possible design parameters and inputs. To be able to objectively manage this computational process, we are still required to understand the architectural implications of its use; those implications involve performance (it ought to serve a purpose), aesthetic (it has to be pleasing to the eye), and structural stability (it has to be structurally sound).

While aesthetical issues are still important as they modify the signification and meaning of the architectural object, we need to fully integrate variable parameters into this process of digital production, including pragmatic issues such as material configuration and programmatic function. In the end, the new architecture of the parametric age ought to perform rather than represent, and it ought to be pragmatically produced and fabricated rather than objectified and fetishized on paper. Computational strategies tend to redirect the attention to processes rather than form while providing solutions that seek the integration of form and material through an evolutionary process that delays form until material feedback has been finalized. Within this framework, homogeneity and seriality are not longer necessary.

ENDNOTES

1. Gilles Deleuze, Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*, Trans. By Brian Massumi (Minneapolis: University of Minnesota Press, 1987), 141.
2. Paul Rabinow, Gaymon Bennett, *Design Human Practices: An Experiment in Synthetic Biology*, (Chicago: University of Chicago Press, 2012), 1.
3. Max Weber, *The City*, (Glencoe, IL: Free Press, 1986).
4. As Turing puts it, "the principles [of his pattern simulator algorithm] . . . should be of some help in interpreting real biological forms." See Lawrence Fogel, *Intelligence Through Simulated Evolution*, (New York: Wiley, 1999), 1-5.
5. Gilles Deleuze, Felix Guattari, 139.
6. Gilles Deleuze, Felix Guattari, 141.
7. Jean-Louis Cohen, *The Future of Architecture Since 1889,* (New York: Phaidon Press, 2011), 14.
8. Kenneth Frampton. *Modern Architecture: A Critical History (Fourth Edition),* (London: Thames & Hudson, 2007), 12-15.
9. Ibid, 33.
10. Manfredo Tafuri, *Architecture and Utopia*, (Cambridge, MA: The MIT Press, 1979), 4.
11. See Charles Jencks, "The Death of Modern Architecture," in The Language of Post-Modern Architecture, (New York: Rizzoli, 1977), 9.
12. Beatriz Colomina, *Architecture Production and Reproduction*, (Princeton, NJ: Princeton Architectural Press, 1988), 10.
13. Felix Guattari, *Chaosmosis*, (Bloomington, IN: Indiana University Press, 1995).
14. Gilles Deleuze, Felix Guattari, 135.
15. Gilles Deleuze, Felix Guattari, 330.
16. See Manuel De Landa, "Nonorganic Life," in *Incorporations*, Edited by Jonathan Crary and Sanford Kwinter, (New York: Zone Books, 1992), 129.
17. Christopher Alexander, *Notes on the Synthesis of Form*, (Cambridge, MA: Harvard University Press, 1964), 1.
18. Ibid, 132.
19. Yona Friedman, *Toward a Scientific Architecture*, (Cambridge, MA: The MIT Press, 1980), 1-5.
20. Robert Corser, *Fabricating Architecture: Selected Readings in Digital Design and Manufacturing*, (Princeton, NJ: Princeton Architectural Press, 2010), 32.

21. Michael Hensel, Achim Menges. *Morpho-Ecologies: Towards Heterogeneous Space in Architecture Design*, (London: AA Publications, 2007), 28.
22. See Patrik Schumacher*, The Autopoiesis of Architecture: A New Framework for Architecture, Vol. I,* (London: John Wiley & Sons, 2012), 1.
23. See Patrik Schumacher: The future is Ready to start, http://theoryagainsttheory.wordpress.com/tag/parametricism/ (accessed July 2, 2012).
24. Patrik Schumacher*,* 2.
25. Branko Kolarevic, Kevin Klinger, *Manufacturing Material Effects: Rethinking Design and Making in Architecture*, (London: Routledge, 2008).