The paper examines the interplay between simple and complex in contemporary architecture. It discusses how complex-looking designs could arise out of simple design and production strategies (i.e. through "simplicity") and likewise, how simple-looking designs can be based on rather complex conceptual and tectonic solutions (i.e. "complicity"). The paper focuses on simplexity as a conceptual framework for architects to embrace complexity in design.

**Keywords:** Simplexity, Complicity

**INTRODUCTION**

The broad adoption of parametric design and digital fabrication in architecture schools and offices in the first decade of this century led to a proliferation of complex-looking designs, often with doubly curved surfaces and highly differentiated components in series, each with a unique shape. This triumph of differentiation over repetition marked a dramatic departure from mass production as one of the basic tenets of Modernism, which premised economic production of buildings on an endless repetition of standardized, identical components. The emergence of geometric modeling software based on NURBS meant that there were no limits to the kinds of complex geometries that could be accurately represented. The computer controlled machinery for subtractive and additive fabrication made complex shapes relatively easily attainable in a variety of materials. Geometric complexity was no longer a barrier, either representationally or production-wise.

Many saw the resulting formal exuberance as an aberration, an unnecessary distraction that would quickly fade out. In some projects, complexity became an end in itself, often leading to unnecessarily complicated designs and tectonic details; however, complexity - whether formal, spatial, programmatic, or tectonic - need not be complicated. Simple rules and processes can produce remarkably complex looking outcomes. As argued later in this paper, simplexity - defined as simple complexity - is seen as a promising way to use effectively digital design and production technologies.

In the sections that follow, complexity and simplicity are briefly discussed, with their manifestations within the disciplinary context of architecture. Simplicity is introduced as a paradoxical notion that synthesizes simplicity and complexity in a productive, conceptually compelling duality, resulting in simple design strategies that may lead to the emergence of complex looking formal outcomes. Such thinking is in line with the complexity theory (Gribbin 2004), but is still at the periphery of interest in contemporary architecture. The principal argument is that new design insights may result from exploring how complexity and simplicity could coexist and co-evolve in the design process.
EXPLAINING COMPLEXITY

According to the Merriam-Webster dictionary, complex means "a group of things that are connected in complicated ways;" complex and complicated are considered as synonyms, with "having confusingly interrelated parts" provided as a definition. The discussion of synonyms, however, does make a distinction later on between the complex and the complicated: complex "suggests the unavoidable result of a necessary combining and does not imply a fault or failure," whereas complicated "applies to what offers great difficulty in understanding, solving, or explaining." Clemens Bellut (2008) examines the distinction between the "complex" and the "complicated" in a similar vein when discussing the concept of complexity from a philosophical perspective: stating that something is complicated means that "the finite number of its determinations cannot be grasped directly," by contrast, saying that something is complex means that "the number of its determinations is simply infinite." He also observes that "something complex [...] can assume the appearance of simplicity, while the complicated always excludes everything simple from itself."

Complexity as a concept is present in many domains, fields and disciplines, carrying a different meaning depending on the context in which it is applied. As Mitchell (2009) points out, however, neither a single science of complexity nor a single complexity theory exists yet. According to Erdi (2008), in most contexts the discussion of complexity is related to the structure of a system. Herbert Simon in his seminal article "Architecture of complexity" published in 1962 defined the principal challenge as finding the right representation to describe complex structures:

"How complex or simple a structure is depends critically upon the way in which we describe it. Most of the complex structures found in the world are enormously redundant, and we can use this redundancy to simplify their description. But to use it, to achieve the simplification, we must find the right representation."

Simon argues that complexity frequently takes the form of hierarchy, as a principal structural scheme in which a complex system is decomposed into several subsystems, which in turn have subsystems, and so on. Simon offers additional insights, describing the dynamic properties of hierarchical systems and how their behavior could be analyzed.

The focus on structure is at a center of the aptly named structuralism, which has emerged in 1960s together with reductionism as a parallel development. The systems theory was developed at that time too, with its discussion of open and closed systems, and the emphasis on interactions between the system and its environment (in open systems). Certain characteristic properties of complex systems were identified early on: the importance of feedback loops, the notion that a small change can cause dramatic effects (the so-called "threshold effect"), and that emergence and unpredictability are essential.

There is a shared understanding in various fields that complexity is dynamic in nature rather than static, which then raised the questions of whether there is a continuum between simplicity and complexity and whether that continuum is linear or non-linear. Furthermore, there is also a question of measuring complexity, as it is rather obvious that some phenomena are less and some are more complex. Kolmogorov has proposed that measuring complexity is rather straightforward: if some system could be described in a concise manner then it is less complex. Kolmogorov complexity, also known as K-complexity and algorithmic complexity, measures the complexity of a given system or a problem by the length of the algorithm that describes it. Kolmogorov complexity is particularly apt in the context of architecture (and visual arts) as it distinguishes between visual and structural complexity. As observed by Jesus Mosterin (2002), "regardless of the complexity involved in the appearance of a pattern, complexity is defined based on the reproducing algorithm, that is, a series of instructions that will generate the visual pattern."

For some, the essence of complexity is that the outcome of the system's operation should not be ob-
vious from its constituent parts and their interactions - all of which could be rather simple. Such structural simplicity seems to be at the core of research aimed at understanding complex phenomena. According to Gribbin (2004), "complexity theory is uncovering the deep simplicity from which complexity arises: simple laws, non-linearity, and sensitivity to initial conditions." It is this "deep" structural simplicity in design systems capable of generating complex formal and spatial outcomes that is the focus of this paper. The topological definition of the design's structure, i.e. the definition of the relationships between its constituent parts plays an essential role in this process. The complexity of a design could be expressed as the length of the algorithmic description of its genesis. What is interesting to note here is that the algorithmic definition of the design is independent of its form; it operates at the structural level.

COMPLEXITY AND SIMPLICITY IN ARCHITECTURE
There is no single definition of complexity in the context of architecture. We talk about complexity as being social, cultural, programmatic, functional, formal, spatial, tectonic, performative, phenomenological... It was Robert Venturi (1966) who famously re-introduced the subject of complexity into architecture; Venturi, however, wasn't specific about the kinds of complexity he was interested in, making references both to historically present complexities in architecture and the complexities associated with the design itself. Around the same time, György Kepes (1965), a Hungarian-American art theoretician, heralded the emergence of movement from the "classical sciences of simplicity toward a modern science of ordered complexity." For Kepes, complexity offered an integrative structural ordering that would interconnect arts, architecture, science and technology. Three decades later, Charles Jencks in his "Architecture of the Jumping Universe" (1995) juxtaposes what he refers to as the "Post-Modern sciences of complexity" to the "Modern sciences of simplicity," with the former sublating the latter. For Jencks, the complexities present in the projects by Peter Eisenman, Frank Gehry, and Daniel Libeskind, for example, are manifestations of broader cultural influences of the emerging sciences of complexity. Jencks makes it clear that architectural form is where complexity manifests itself.

Arguably, Modernism was about simplification in architecture, succinctly articulated as "less is more" by Mies van der Rohe. The resulting monotonic simplicity in urban contexts is what Robert Venturi's was reacting to. Venturi was interested in the effects that buildings have on the perceptions; Modern architecture with its stripped down articulation of surfaces and simple forms didn't offer much to the eye. It was the absence of surface ornamentation and complex forms that arguably made the minimalist aesthetics of Modernism less affectionate (Kolarevic and Klinger 2008), contributing in part to its demise.

According to Ernst Gombrich (1979), the human mind has an intrinsic need for "careful balance" between complexity and order. The mind has no trouble deconstructing a simple, regular grid (i.e. recognizing the monotonous); it quickly "disconnects" in reading complex configurations if it cannot recognize an underlying structure. Gombrich argues that a "careful balance" between these two conditions, i.e. between monotony and complexity, is what the mind looks for in its constant processing of the surrounding environments. In that vein, the infatuation with complex geometry in mid-1990s soon was replaced by the exploration of highly crafted, non-uniform surface effects based on complex pattern-generating, texturing, or relief (Kolarevic and Klinger 2008).

COMPLICITY AND SIMPLEXITY
In the history or architecture complexity and simplicity have generally been considered as contrary notions. The complexity science demonstrates otherwise, that simplicity and complexity are interdependent and mutually coexisting. As noted by complexity theorists, there is a dialectical interplay between simplicity and complexity (Gribbin 2004). Complexity can arise out of simplicity, and likewise, simplic-
ity can arise out of complexity, giving rise to sim-plexity and complicity, respectively, as new concepts that capture the interdependence and coexistence of complexity and simplicity and interaction and emergence that is implied. The exact origins of these terms are not clear. Jack Cohen and Ian Stewart (1995) define complicity and simplexity interchangeably as "interaction between coevolving systems that supports a tendency toward complexity" and a "simpler order to emerge from complexity". For Jeffrey Kruger (2008), simplexity is about a "complementary relationship between complexity and simplicity". Obviously, complicity and simplexity are hybrid, related concepts framed by a synergetic relationship between simplicity and complexity. In my view, simplexity can be defined as simple complexity and, likewise, complicity as complex simplicity.

Simplexity is compelling because it offers a way of describing seemingly complex outcomes by relatively few simple rules and interactions. Simple, straightforward rules may facilitate the emergence of highly complex designs by defining a direction without confining it. This conditioned emergence can lead to shapes, forms, and spatial organizations that look surprisingly complex, yet, at the core, are generated by a system based on simple rules. (Cellular automata are an example of simplexity, where simple rules can lead to startlingly complex outcomes.)

Intentional simplicity, however, can be problematic, because a single goal, single focus, single preoccupation can preclude consideration of any others. Simplicity may thus diminish the consideration of other, often more promising options that exist on the periphery and favor "exploitation" over exploration. A reductive spiral of simplicity can be often counterproductive in design. But, as Obendorf (2009) observes, "reduction is the path to simplicity, and minimalism describes paths to approach reduction." He argues for minimalism as a "tool to think about the simple and to discover and instantiate patterns for designing simplicity." Generating visual, spatial, or formal complexity with minimal means, minimal structure, is actually not that simple. It requires careful deliberation and selection of influences that would affect the designs that could emerge from the operation of the system.

**ECONOMY OF METHOD**

After seeing many students hopelessly entangled in complicated complexities of their own making, it became apparent rather quickly that teaching (or "preaching") of complexity requires a pedagogic refinement. As argued earlier, complexity - whether formal, spatial, programmatic, or tectonic - need not be complicated. Simple rules and processes can produce remarkably complex looking outcomes. A particularly potent example of a complex-looking design based on simple rules is the design for the Serpentine Pavilion in London (2002, figure 1) by Cecil Balmond and Toyo Ito. The apparently random patterning that wraps the entire pavilion is produced by incremental scaling and rotation of a series of inscribed squares, whose edges were extended and trimmed by the pavilion's unfolded box shape (figure 2) to create a beautiful, seemingly irregular-looking pattern of alternating voids and solids.

There are numerous examples of designers using design strategies based on simple rules to produce complex looking visual, surface, spatial or formal outcomes (Kolarevic and Klinger, 2008). Such complexity based on simplicity - that is, simplexity - implies a certain economy of method that became the essence of my design teaching over the past decade. To explore the relationship between complexity and simplicity and to understand their interplay, I have asked students to produce relatively quickly, in an iterative fashion over five weeks, a series of self-similar, complex looking objects by defining simple parametric and production processes. An important design and production dimension of the exercise was a certain "economy of method," introduced as "less effort, less machine time, less material, less waste," and summed up in the end as "less for more" - a thinly veiled reference to Mies van der Rohe's famous motto, but with an entirely different connotation. This design/production dimension was an attempt...
Figure 1
The Serpentine Pavilion in London (2002), designed by Cecil Balmond and Toyo Ito.

Figure 2
Serpentine Pavilion: the irregular-looking pattern is based on incremental scaling and rotation of a series of inscribed squares.
to introduce resource economy (time-, material-, and energy-wise) into the design and production processes. Complex effects were to be achieved through simple means; the underlying ethos being that complexity need not be synonymous with complicated, i.e. that conceptual and production simplicity can produce a perception of complexity in the outcome.

Expanded Topographies (figure 3), a project by Dustin Headley completed in 2006 at Ball State University, offers a particularly successful demonstration of such a resource economy approach to design and production. It was inspired by research into expanded metal meshes, which are produced by simultaneous slitting and stretching of a flat sheet of metal, resulting in a regular, repetitive pattern of diamond-shaped holes. What is interesting about this process is its geometric and production simplicity, and that nearly zero metal waste is generated during the process; in addition, the final product - the expanded mesh - is stronger (by kilogram) and lighter (by meter) than the original sheet.

The project’s premise was that variegated surface patterns, i.e. apertures of gradually increasing or decreasing sizes, could be produced by simply varying the values of expansion parameters including the length of cut, aligned spacing between the cuts, and spacing between the successive lines of cuts. Using scripting in Rhinoceros, a simple parametric procedure automatically generated different cutting patterns (figure 4), which could be directly transmitted to a digitally controlled cutting machine. Various prototypes were produced by laser-cutting flat, rectangular sheets of acrylic, which were then heated and expanded by applying equal force (in opposite di-
rections) to the two shorter sides of the sheet. The sheets would deform in the process, depending on the density and the lengths of the cuts, producing topographic surfaces, with apertures that vary in size across the length of the surface. Precise topographies were produced by controlling the length of each cut and X and Y spacing between the adjacent cuts. In addition, by making non-parallel cuts, i.e. by introducing angle as an additional parameter, further possibilities for surface articulation opened up. The design and production processes were simple and straightforward, with nearly zero material waste, resulting in an artifact with intricate surface effects, subtle undulations and series of apertures that change in size across the length of the panel.

CONCLUSION
The multiplicity of opposite meanings associated with simplicity and complexity in architecture and the implied paradoxical relationship between the two actually open up interesting opportunities to explore them in a non-dichotomous way. The dialectical relationship between the two could be very productive, as demonstrated by a number of authors from a very broad range of disciplines and fields, who argue that complexity and simplicity coexist and imply each other in so many different contexts. Thinking of them as diametrical opposites diminishes the productive role of simplicity in understanding complexity (and vice-versa). The principal argument is that simplicity is an elegant, efficient, way to produce complexity in architecture. The resulting simplicity could indeed be the source of new conceptual "minimalism" in architecture.

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