COMPUTATIONAL THINKING WITH ANALOGUE AND DIGITAL MEANS

The architectural drawing as a parametric tool since late modernism

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Abstract. By elaborating on the significance of the drawing in the architectural avant-garde of the 1960s, the paper’s primary scope is to weave a thread between late modernism and contemporary research in computational design. The architectural drawing is presented as an abstract means aiding design research. The more recent notion of performative drawing evokes adaptability, being a critical precondition that responds to diverse design aims in interactive manners. Performative drawing’s function may further be linked to patterns, a recurring research theme during late modernism. Thinking in (and with) patterns recalls approaching design problems through malleable schemas that hold design data, according to which they are being transformed. In respect, the present paper delves into the analogies between the manipulation of patterns with the use of drawings during late modernism and parametric processes developed through simulation patterns of the current era. Through this comparison, it becomes possible to stress out the operative significance of methodologies and conceptual means in the architectural making as tools that are being used primarily for the exploration of form’s dynamic behaviour.

Keywords. Patterns; parametric architecture; late modernism; performative drawing; simulation.

1. Introduction

The origins of computation in architecture may be traced back to structural approaches of the 1960s. The connection is twofold. Design experimentation of late modern avant-garde was based on the quest of organizing patterns on the one hand and the exploitation of the drawing as a means for their spatial
adaptation on the other. The interest on patterns of that era may thus be described as a scrutinized study of their structural properties being graphically expressed and translated according to specified design aims. It is argued that patterns were not merely viewed as geometric motifs, but rather as intelligent systems interacting with data influencing design, capable of sustaining spatial development in totalizing manners. By defining new techniques and by following iterative operations, the intermediary findings were practically treated as transitional steps presented in sophisticated styles. The exhaustive exploration of structural models, open systems and schemas of the architectural avant-garde of the 1960s set the trajectory for more innovative methods, means and techniques that ensued, culminating with contemporary research in computational design; the presented research is all occurring at an abstract level purposefully disassociated from formal and aesthetic precepts, essentially preparing the ground for dynamic processes studying behaviour, responsive transformation and expansion (Liotta, 2012).

In respect, the paper's scope is to draw a link between computational design in architecture with main discourse themes factually set along with the endeavours of modern and late modern era. The avoidance of attributing value to 20th century precedents commonly seen in current debates is somewhat comprehensible, especially since setting avant-garde's own character often infers drawing apart from its recent past. Alternatively, it may be argued that contemporary research in architectural design is very much a consequence of the means in use and the appointed methods of production, whereas their goals are to a large extent updates of those set in the course of modernism. In examining such a view, methods and approaches of 1960s avant-garde are compared to processes of design exploration with advanced digital tools applied onto archetypical shapes, patterns and data about a project. The emerging analogies show the affinities and the transitory ideas between past and present, further outlining the significance of the proposed historical thread.

2. Computational thinking. Drawing in the 1960s

2.1. THE PERFORMATIVE DRAWING

Abstraction in design would bring about an analysis of a problem to a set of variables for comparison in the virtual environment of a model set specifically for a case. By means of abstraction, an element is broken down to its properties and presented as in the form of a diagrammatic drawing. The drawing is viewed as a reduced visualization of the reality it represents. The level of abstraction is granted on the basis of a clear understanding of what is
omitted from the representation (Schumacher, 2010). An understanding of the drawing as an abstract model assumes that the produced graphemes yield their normative features to a structure, whereat openness at an interpretive level provides with the flexibility required in each of the creative steps.

The integration of advanced software especially in the initial phases of design has further supported the exploration of abstract qualities about drawings through digitally based techniques. As Frazer (1995) suggests, the computer may be used not as an explanatory aid in the usual sense, but as an evolutionary accelerator and a generative force, helping to envision "a new form of designed artefact interacting and evolving in harmony with natural forces, including those of society." The computer may equip the design process with the mechanisms needed to continually capture the forces (visible as well as invisible ones) that shape society as material to work with and to become connected to culture (Moussavi, 2008 and Liotta, 2012). Architectural concepts may be expressed as rules, continuously tested and updated. Virtually any of these rules may be described by a genetic language producing a code-script of instructions for form generation (Frazer, 1995). This code is expressed in the drawings as lines and shapes. The created graphic instances remain intentionally vague: lines may signify walls, beams, shifts in materiality or mere trajectories of movement (Figure 1). This implies a shift away from the false certainties of visualization towards the generative functions related to the computer as an abstract machine, an iterative, diagrammatic and relational device (Schumacher, 2010). As these innovations have been imbued in the creative phases of design, the computer has caused a comprehensive revision of the drawing through alternative formations for the exploration of new forms of expression.

![Figure 1. Zavoleas, Patsavos, Yiannoudes, 2012 (Ctrl_Space Lab): "Top-Down, " Rethink Athens competition (short listed). Study of urban activities along a central pedestrian artery.](image-url)
In respect, the drawing is not limited to technical information. A rough sketch showing connections, changes and flows, triggers a dialogue among the elements involved, with the profound scope to push creativity forward, rather than to document design at a fixed stage. As Allen (2000) has pointed out, "the architectural drawing is transitive in nature, uniquely capable of producing something new from something else." Design is driven by intentions and a methodology as in real-time simulated experiments, meanwhile remaining blind to the eventual outcome (Frazer, 1995). A drawing is set regarding its "position and role in the chain of translation from one drawing to the next (more detailed) drawing, and from there to the construction process and the building itself" (Schumacher, 2010). Drawings act as dynamic entities interacting with the design variables as they respond to critical data about a project towards completion. The produced results are subject to constant interpretation and assessment, so that through recursive operations a series of alternatives is developed, gradually leading to more refined versions. The initiated discourse is about relationships, boundaries and energies, having the poetic and pertinent potential to precisely promote performances (Liotta, 2012). The drawing may thus be viewed as a performative model where the design emerges, rather than a descriptive means used solely for representational – after the fact – purposes.

Performative drawings ought to be viewed as mental constructs acquiring significance by delivering some information about how things are related and not by visually denoting shape and form. Such an effect is further intensified with the evolution of dynamic modelling software supporting dependencies among the design elements, with which it is possible to revisit any of the intermediary decisions and inform the later drawings with updated data (Allen, 2000). Performative drawings initiate processes of interaction between their signs and the increments of data as agents acting onto the scene. Drawings’ beauty resides in their contributing role in the design process, in so doing offering new paths for the designer’s imagination.

2.2. DRAWING WITH PATTERNS

A set of similarities may be drawn between the notions of performative drawing and patterns, specifically in view of the ways the latter ones were employed in architectural research as non-hierarchical structures or – more accurately stated – structures at a varying degree of order. Non-hierarchical structures are geometric aggregations initially set with minimum classification and rules, made to interact with data, as due to this interaction their geometric uniformity is partially damaged. Pioneer architects of late modern
avant-garde elaborated on patterns initially deployed as de-centred structures turning to multi-centred ones in response to the complexities of a design problem. Pattern adaptiveness evokes a perceptive shift in their conception from rigid elements being subordinate to geometric rules set in advance to ‘soft’ ones in feedback communication with the design variables.

Such a shift may even be linked to an increasing interest in topological geometries, that is, fluid ones not being defined as derivatives of geometric shapes. Geometry was frequently employed in modern architecture as a quest on platonic solids. Rowe (1947) for example explores the geometric analogies between Le Corbusier’s Villas and those of Palladio over Renaissance. In a similar style, Le Corbusier’s Modulor system describes geometric relations based on the ratios of the human body, as a sort of revival of da Vinci’s Vitruvian Man also from Renaissance, which recalls Vitruvius’s references to beauty following proportional modular systems. Le Corbusier's Modulor was further enriched with meanings of ergonomy and functionality – also typical themes of modernism – as for this reason Modulor was included in Neufert’s Architect’s Data handbook. All in all, an understanding of patterns as malleable geometric entities over late modern avant-garde invokes disengaging from aesthetic norms, in so doing challenging a long-term tradition eventually helping to break from established building types towards new compositions.

Figure 2. Doxiadis, 1963, study on regional plan for Greater Mussayib in Iraq, showing structural resemblance with natural phenomena.

An increase of interest in the study of patterns during the 1960s was part of the recognition that they hold an operative value going far beyond mere decoration promoting a function that links anything organic to its environ-
ment, also to mutation and evolution. An acknowledgement of the organic would be extended to a general quest for the adaptation of structural patterns to all aspects of human activity. Doxiadis’ (1963 and 1968; Zavoleas, 2013) research on human settlements was based on the observation that patterns retain dynamic qualities permitting them to adjust in response to change, as by this means they obviate decay and death (Figure 2). Similar views were adopted by other architects such as those of TEAM 10 and even late Le Corbusier, proposing an architecture whose behaviour at micro and macro scale was defined by the appointed patterns and the modes of their adaptation. Later, research was enriched with the incorporation of methods related to the quantification of data and its comparative manipulation for the development of holistic design approaches. Examples of this framework include Alexander’s *Pattern Language* in the 1970s, followed by Hillier’s *Space Syntax* in the 1980s and Frazer’s *Evolutionary Architecture* in the 1990s. The above works’ main intention was to systematize spatial analysis and composition first by recognizing existing patterns, then by using them as ‘raw material’ for spatial reconfiguration. In short, patterns’ integration to architecture happened along with their pertinence in research and the scientific study of natural and biological phenomena often developed in other areas such as artificial intelligence and computer science.

The research on patterns over the past decades has drawn upon a strand that is virtually parallel to the evolution of computational thinking. The related processes were associated with the examination of space along with the development of generative scenarios. Hence, it was possible to elaborate on the farfetched idea of space being an entity that follows patterns of evolution, thereby to foresee, as Spyropoulos (2009) has remarked, "an architecture that combines the biological and computational as an adaptive and evolving organism." For this, it was critical to view patterns as highly intelligent systems for development in space and time, being also able of holding the intricacies of reality at an organizational level that associates with – albeit not exhausted by – the physical and the tangible. Such an idea is stretched further with the employment of computational means. As Anderson and Salomon (2010) have described, patterns provide "architects with a device to connect apparently incongruent categories and synthesize a multitude of performances, project requirements and informational types in a perception-based medium." Admittedly, much before the computer sponsored pattern development to a burst, computational thinking was already infused in their study as a competent set of terms, graphic languages, methods and techniques, drawing from a wide asset of references, ranging from the diagrammatic and the experimental to the material and the experiential (Kwinter, 2010); or, from pure science to common practice (Figure 3).
Patterns’ polyvalent relevance to architecture relies on the fact that they convey their structural properties first to the material substance of the media at use, then to the behaviour of physical space, matter, scale and form. Patterns are latent substances with multiple operative qualities. In that case, potentiality relies on their resilience to incarnate into a variety of tangible elements whose structure remains negotiable, also on their operational value as connecting agents, being able to articulate space and produce diversity and beauty; in that case, the use of patterns is defined by their operational significance and the realization of divergent potentialities (Benjamin, 2012). Patterns are symbolic abstractions of their properties being transmitted to their material manifestations and by which they are being defined. They are symbolic to the extent that they are the simplest as well as the clearest expressions of the properties they hold, having been stripped of any material implication; they are abstractions as far as they do not have any well-defined, unitary function and yet they acquire new functions as they are adapted to different case scenarios (Liotta, 2012). Pattern adaptation includes modification by adding or subtracting parts, also by distorting the perspective, rotating and/or mirroring the base motif. Through transformations, patterns help to enact genuine exchange, producing spaces that are hybrid in nature, open and inclusive, rather than fixed, rigid and exclusive. As such, they remain unifying substrates: "the management and exploitation of trans-scalar relationships of pattern is the source of structural ‘performance’" (Kwinter, 2010). In effect, the significance of patterns goes much beyond what would be a mere repetition over what it organizes, or even a skin effect: patterns outline the performative arena onto which the active forces of design manifest their hierarchies, analogies and compromises, as they share a place, a size, a form, a role and an identity in the total composition.
3. Digitally driven design. The drawing as a simulation model

A further revision of the design process is happening along with the evolution of the study on behavioural patterns. Behaviour links to the idea of data understood as active variables, by also taking advantage of the computational power in simulating patterns of interaction. As Carpo (2011) remarks, today's digital designers are no longer working on notations of objects, but on interactive avatars (or informational models) of the objects themselves. Digital design applications are tools for designing and making at the same time. The employment of parametric and generative processes calls for an even more dynamic understanding of the organic, managing cultural parameters as active forces in a constant state of becoming (Liotta, 2012). The project evolves as a sophisticated system interfacing between urban, building and material scales of operation, engaged through negotiation (Spyropoulos, 2009). The design process makes use of the drawing, whose performative attributes are described as potentiality, interpretive variability and functional diversity.

Figure 4. Zavoleas, 1999: Urban Transitions, Venice CA. Sketch studying the design variables as forces interacting with the site.

In fact, these attributes are inherent even to common design practices, as they may be compared to the operative uses of the handmade sketch (Figure 4). The abundances of the line, with its variations and openness of meaning, result from processes of topographic writing as intuitive registrations of forces onto the tracing paper (Vidler, 2010). A view of the line as a topographic instance recalls generative processes of digital writing with advanced design software. In analogy, the digital model is 'purified,' that is,
left without any information considered to be irrelevant to the project, mapping only the significant data and projecting it onto the digital form. The produced topographies, Vidler (2010) explains, "include in their modelling ‘data’ that would normally be separately diagrammed – the flows of traffic, changes in climate, orientation, existing settlement, demographic trends and the like. Formerly these would be considered by the designer as ‘influences’ to be taken into account while preparing a ‘solution’ to the varied problems they posed. Now, however, they can be mapped synthetically as direct topographical information, weighted according to their hierarchical importance, literally transforming the shape of the ground.” The dynamic character of the digital model begets a shift in the definition of form as a weak shape or system that maps the particle forces meanwhile being transformed by them as in a real-time process. Design is about the parametric simulation of these forces setting their portion of influences in manipulating the project. The drawing coincides with the parametric diagram. It acts as a scene that simulates behaviours. It performs as a model influenced by parametric data, as through iterative interactions it will eventually be translated in the form of the produced space (Figure 5).

Figure 5. Zavoleas, Xanthopoulos, Zindrou, 2013 (Ctrl_Space Lab and Ahylo): Eleftherias Square, Thessaloniki, Greece. Diagram of forces and real-time simulation.

8. Conclusion

The present paper's main scope was to build up a connecting thread between the operative function of the drawing of late modern avant-garde and contemporary research using computational methods in architectural design. In the 1960s, the architectural drawing was appointed for the examination of patterns as conceptual means for spatial organization, manipulation and definition. An excessive exploration of patterns' structural capabilities in the architecture of that era was based on the assumption that the drawing was essentially a simulation model showing design variables, whose properties were negotiated at global and local scale.
Analogue methods and techniques applied onto patterns along with computational means simulating behaviour produce new design concepts and strategies. On the one hand, design would be about a quest of agents acting as generative forces directly onto form, whose spatial manifestations vary significantly at changing conditions. On the other hand, research would be directed towards testing the ‘material’ properties in the digital set along with an increasing interest in sustainable systems relating dynamically the different scales from the molecular to the overall form and back. These themes are brought together again under an updated view about design, which assumes the organic interconnectedness of all elements making up space, additionally the ability to reconfigure space as a varying entity, an idea that is inherent in the concept of the organic, too. Such a view underpins the dependencies between data influencing design and architectural form, in so doing bypassing aesthetic and geometric fixities in favour of dynamic behaviour, as in a neostreamalist approach. Overall, it may be stated that an understanding of the digital revolution in design in conjunction with the late modern studies on patterns as structural systems having dynamic behaviour has given a rich set of criteria largely applicable in current architectural discourse.

References