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To cite this version:
Ioanna Symeonidou, Phivos-Angelos Kollias. SYN-THESIS: An insight into the correlations in architectural and musical algorithmic composition. Knowing (by) Designing Conference, May 2013, Brussels, Belgium. <hal-01664509>

HAL Id: hal-01664509
https://hal.archives-ouvertes.fr/hal-01664509
Submitted on 14 Dec 2017

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Syn-Thesis

An insight into the correlations in architectural and musical algorithmic composition

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Abstract. This paper is exploring correlations in the creative process of algorithmic composition in both architecture and music. It is product of a collaborative effort between the two disciplines, aiming to inform architects and composers about similarities and differences of the creative process. More specifically the attempt is to investigate the dynamic transformation of a composition through its entire lifespan: starting with the “genesis” of a creative idea, then the representation of intentions, through the dynamic development of a project influenced by different factors, which leads to the user experience of the final result. The interdisciplinary approach used is both in terms of the interaction between the two disciplines and the use of concepts, like those of emergence and self-organization. Some of the factors examined through such perspective are the decision making process during composition and the evolution of a design or musical piece.

Keywords. architecture; music; algorithmic composition; interdisciplinarity; self-organization; emergence.

Introduction: An interdisciplinary approach

The advantages of an interdisciplinary approach, like the use of the meta-language of complex systems studies, are numerous. On the one hand, different disciplines sharing similar questions, can communicate through a common language.¹ In this manner, the different disciplines can collaborate in order to find answers using methodologies coming from different fields. On the other hand, the results of the interdisciplinary research can be equally applied in those individual fields.

More specifically, if we consider an interdisciplinary approach in composition – whether this is architecture or music – the direct application of such concepts can result in new techniques of production. Furthermore, this perspective can lead to a re-conceptualisation of the current practice, away from the restrictions of conventional approaches, giving birth to a new viewpoint. Notably, Iannis Xenakis² suggested a new type of “artist-conceptor” of abstract and free forms, who is capable of using knowledge of different scientific and humanistic disciplines, and who possesses a kind of universality based on the “forms and architectures” of those diverse disciplines (Xenakis, 1979).

¹ Notably, two of the most important interdisciplinary domains, cybernetics and general systems theory, were mainly organised to connect different scientific domains though a common language. Wiener writes about his ‘conviction that the most fruitful areas for the growth of the sciences were those which had been neglected as a no-man’s land between the various established fields’ (Wiener, 1948/1965). The Society for General Systems Research organised on 1954, states as the first of their major functions to ‘investigate the isomorphy of concepts, laws, and models in various fields, and to help in useful transfers from one field to another’ (von Bertalanffy 1968/2006).
² Xenakis (1922-2001) is widely known for his connection of scientific disciplines and music, and in particularly for his foundation on architecture.
We will attempt here through a creative dialogue between an architect and a composer, to find correlations within the creative process of algorithmic composition in both fields.

**Algorithmic composition**

An algorithm is ‘a set of rules for solving a problem in a finite number of steps’ (The American Heritage Science Dictionary). In this manner, a problem needs to be codified in a certain mode according to the discipline it serves and through a set of rules to proceed to the solution of the problem.

Algorithms are traditionally used in mathematics and computer science, but when employed for creative disciplines such as music or architecture, they can be seen as computational tools that lead towards the production of novel concepts, ideas, forms, sounds, “which, in turn, have an effect in the way designers think thereafter” (Terzidis, 2006). Algorithms, especially those following the model of complex systems exhibiting emergent form, include several different approaches resulting in diverse results. However, they are connected by the following related characteristics: (1) simple rules generate complex behaviour, (2) the component elements act as interacting cells or quanta, and (3) global behaviour emerges over large numbers of iterations (Truax 2003).

With the term algorithmic architecture we refer to geometric explorations that follow certain rules set by the designer. As Terzidis explains, “for architects, algorithmic design enables the role of the designer to shift from ‘architecture programming’ to ‘programming architecture’” (Terzidis, 2006).

Current architectural practice has embraced the use of computational processes, giving rise to numerous well established research paths, including among others algorithmic and parametric design. Algorithmic design is a method, usually including one or more ‘if’ statements, driving a design process according to certain criteria. In this practice, complex forms deriving from simple rules are applied for the transformation, multiplication or other modifications of architectural elements. Parametric design defines a strategy, where geometric components of an architectural object are connected through defined relationships. Through the rules of associativity, changes in one element of the composition propagate changes in the entire system. “If the parametric is a technique for the holistic control and manipulation of design objects at all scales from part to whole, the algorithmic is a method of generation, producing complex forms and structures based on simple component rules” (Sakamoto et al 2008).


The use of algorithms to produce a work can be applied in different levels of creation, such as extracting sound structures or defining the structural characteristics in time. Instead, other compositional levels or parameters may be assigned to other creative methods, like for instance the intuitive choice of the composer, the factor of chance or the interpretation capability of a performer. The compositional attitude of using algorithms to determine some aspects of the resulting work is also referred to as computer assisted composition (CAC).

Clearly, it is not easy to define where the limits of the algorithm’s performance stop and where other factors start taking place, like the performer’s choice or other conditions of the performance. Considering ‘rigid’ algorithmic composition where we
are fully defining the work by algorithmic processes, including every individual music parameter and every performance aspect. Even in this extreme case, in reality it is impossible to include every aspect of a work within the creative algorithm.

It is evident that computational tools, and more specifically algorithmic processes, have marked a turning point in both disciplines. An architect or a composer designs the rules rather than the end product. The computer is not merely a medium for the representation of ideas; rather it is a tool for decision making, simulation, evaluation and form generation. As Truax puts it, there is a shift of “the role of the artist from the person who is required to generate every detail of the intended result, to one who guides the processes that produce the result” (Truax 2003).

The creative process

A creative process is not easy to trace, as it is usually a non-linear sequence of events depending on different factors. However, for the sake of analysis and argumentation, we dissect the creative process in three phases, which are either discrete or integrated. Regarding architectural creation we distinguish: (1) Architectural morphogenesis with algorithms aiding the creative process (2) Representation of the idea or design documents (such as plans-blueprints) (3) The architectural end product.

Considering musical composition, these three phases can vary accordingly: (1) Creation or collection of music material (2) Detailed structuring of the material in time by representation (such as traditional or graphic notation) (3) The performance as a sound realisation in time and space.

In both disciplines, these three phases can employ either analogue or digital tools. They can act as discrete phases from the conceptual to the actual, or as an integrated process; a creative idea is materialised through the aid of computers, incorporating all stages of the creative process. It is possible that the tools employed for the development of the composition can affect the sequence of events as well as the mapping of intentions from composition to materialisation.

In architecture, parametric modelling is introduced as a method of using external data and enabling adaptation of architectural elements according to local or global rules. The majority of contemporary architects explore associative modelling through visual scripting interfaces such as Grasshopper plugin in Rhino (Fig.1a), or by writing code within any of the known 3D software platforms, using scripting languages such as VB, Python, MEL, C++ among others. Visual scripting interfaces like Grasshopper have become very popular among practitioners and students of architecture, as its visual interface can offer a direct overview of the rules of associativity in a model.

Accordingly, in music several programs exist for algorithmic composition, whether the approach is computer-assisted composition and the result is a score or the aim is purely electronic music coming directly out of speakers. OpenMusic (Fig.1b) and PWGL are both object-oriented visual programming environments based on Lisp programming language. The user interacts with visual objects by connecting them. The main aim is to extract symbolic information in the form of notation, which can be evaluated through MIDI playback. These tools are mainly used in order to produce a score that will then be performed by musicians. However, Max and Pure Data, two widely used software of object-oriented visual programming are more orientated towards direct electronic sound result.
In several cases, the above mentioned three phases can be partially omitted or integrated. Very often contemporary creative practice tends to bridge the first with the third phase, therefore skipping the phase of representation (blueprint or score). For instance in architecture, a file-to-factory (F2F) “refers to the seamless merging of the design process into fabrication. It involves direct transfer of data from a 3D modelling software to a CNC (Computer Numerically Controlled) machine” (Oosterhuis et al 2004). Such practice changes the role of architectural drawing, as an intermediate step between representation of ideas and construction document. Thus there is a direct link between the conceptual and the actual.

Accordingly, music representation (second phase) is crucial when it is addressed to musicians. However, there are also cases where it is unnecessary, like when we are dealing with improvised or live electronic music. Furthermore, in some cases there is a strong attitude against representation, like in the interactive music of Agostino Di Scipio, where the music work is viewed as a self-organizing system and sound organises itself (Di Scipio 2003).

In another compositional approach, although the work will be performed by musicians, there is no score or another way of representation (again the second phase is omitted). In this case, the composer works closely with the particular musicians who are going to perform the work and the resulting work emerges during their creative collaboration. These are cases like composers George Aperghis and Pascale Criton.

Self-organization in the creative process

Self-organizing systems exposing emergent properties are present in music as well as in architecture.4 Several questions emerge concerning dynamic creative processes in music and architecture, where the representation of events plays a crucial role. How to represent a dynamic process? Where the control on the result ends and interpretation/improvisation begins? Which are the fixed and which the flexible parts of the composition? What is the relation between the parts and the whole? Architectural or musical elements are connected through rules of associativity between events, where temporal, geometrical or morphological variations are propagated by other events.

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4 The concepts of emergence and self-organization are of central significance in interdisciplinary studies. According to De Wolf and Holvoet “a system exhibits emergence when there are coherent emergents [such as properties, behaviour, structure, patterns] at the macro-level that dynamically arise from the interactions between the parts at the micro-level. Such emergents are novel w.r.t. the individual parts of the system” (De Wolf & Holvoet 2004). Likewise, “self-organisation is a dynamical and adaptive process where systems acquire and maintain structure themselves, without external control” (ibid.).
Let us consider the creative process of algorithmic composition as a self-organizing system, where the work is formed inside its given environment of creation. In this manner, in both architecture and music a feedback loop is connected with the product, influencing the creative process. The external feedback may be a condition in the environment. Such condition could be analogue, like gravity and spatial resonance; computational; an agent like soloist, performer or designer/engineer; even a user-auditor.

Self-organizing approach of architectural form finding, to which Frei Otto refers to as “autonomous formations” (Nerdinger et al 2005), is a method implemented either in physical or digital environments. In this method a material system self-organizes reacting to external forces, optimizing this way its overall configuration. Design through processes of simulation and evaluation, is not a new concept, as there are important examples throughout the history of architecture that employed analogue form-finding. Gaudi’s hanging chains (Fig.2) and Frei Otto’s membrane models are some of the most famous examples employing analogue form-finding techniques for structural optimization. In such models, the material self-organizes influenced by extrinsic forces (such as gravity, surface tension or wind load). The forms obtained are optimised for the given performance criteria.

Moving towards a more performance-oriented architecture, the role of feedback in form generation becomes crucial. In the case of genetic algorithms, feedback is incorporated in the creative process, in which the object is constantly adapting according to given criteria. By measuring the environmental performance of an architectural structure and feeding the collected data into the algorithm, a feedback loop is established encouraging the growth of constantly optimized architectures.

Similarly in music, a special case of live interactive composition is the self-organizing work of music (Kollias 2011). The music work emerges during the performance from “the interactions between some predefined structures and an occasional context of performance, through a particular interpretational model” (Kollias 2008). In other words, the composer conceives certain ‘structures’ while he defines the work’s ‘interpretational model’, that is to say, the way these structures will be interpreted by the self-organizing work during any ‘occasional performance’.

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Conclusions
Algorithmic composition in both architecture and music has gained significant attention in the international scene. Leading practitioners have experimented with algorithms in architecture, setting the foundations for architectural innovation manifested in built examples as well as in academic research. At the same time the use of algorithms in musical composition opens up the creative process to new approaches inspired by complex systems. As observed above these two disciplines are developing in parallel, both in a technical level, with tools that assist the composition, as well as in conceptual level, reinventing the role of the architect/composer in the creative process.

This paper is a first attempt of the authors to highlight the correlations in both disciplines and how these disciplines could cross-inform each other. Future research will focus on each aspect of the creative process, in order to abstract and merge design strategies from both practices, leading to a ‘synthesis’ of concepts, tools and methodologies. An interdisciplinary approach to the creative process would encourage the emergence of new perspectives in composition, opening up the repertoire to innovative methods and hence innovative projects.

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