Understanding Complexity in Contemporary Music a Computational Approach

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Abstract

This paper discusses a computational approach to the study of complexity in contemporary music, with the hope that it can shed new light on some (post)modern musical issues. The approach can be summarized as a synthetic analysis of music complexity, in which the capacity of a musical formal system to appropiately express 'complex' contemporary musical textures is evaluated by an analysis of the correlation between the control of the system with the perceptually relevant features of the musical output. The 'musicality' of the result, defined as the convergence of the 'complexity of syntax' with the 'complexity of meaning' can be interpreted as an emergent characteristic of the system. Instrumental music written by the author using this approach is presented. Finally, the limitations are discussed, as well as future directions.

1. Formalism and composition since 1950.

Since the second half of the XXth century, there has been a wide and influential interest in compositional systems that result in 'complex' music. Hyperrationalistic or stochastic approaches have been concerned with formal procedures in which all the materials of a piece, for the sake of organic unity, are obtained by an intensive application of formal methods to an initial set of musical data. The expectation has been that any resulting materials could be interrelated in some or another level or parameter.

The main achievement of this view of composition, which has produced an impressively diverse amount of repertory that counts many masterpieces, has been the redefinition of musical language and the revolution in our conception of music. All currents of contemporary music have been influenced at some point by the shift of interest of music language from notes, motives, harmony, etc. to textures, timbre, micro/macro time, space, etc. However, the formalistic approach also has paradoxically resulted in a loss of comprehensibility of the musical discourse, because our mind may not be able to segment and recognize the patterns that arise in the formal features in the piece.

As a result, many composers have adopted a 'mixed' approach, in which the material is generated by formal systems, but its organization and articulation is done intuitively. The goal of organic unity is contradicted in this way, and serious issues are raised about the purpose and relevance of a systematic use of formal systems in composition. Therefore, a very confusing situation has emerged in theory of the late 20th century music, because, for many important pieces of the new repertory, the analytical challenge of reconstructing the grammar of a piece (what is the initial data, which are the operations employed, how the piece has been derived, etc.) may not be possible to realize starting only from the notation of the piece. The situation is even more delicate if perceptual issues are to be taken into account

It is thus important to make a distinction between what could be called "complexity of syntax", which would relate to the difficulty than an analyst faces reconstructing the grammar given the score, with the notion of "complexity of meaning", which would relate to the capacity that the different sonorities and gestures of the piece have to interact with the psychological space of the listener. With this distinction in mind, we could consider the phenomenon of 'musicality' as a convergence of those two complexities.

After all, the power of tonal music lies in the fact that the tonal and motivic processes can be projected as psychological phenomena in the mind of the listener, making the musical architecture transparent and revealing the compositional procedures.

2. Complexity and simulation.

Since its apparition, the computer has been widely used in simulations to find numerical solutions to problems for which an analytical solution does not exist. Without computational methods, it would have been impossible to obtain insight into a large amount of phenomena, as for instance, how an aircraft wing would react to air turbulence, or how the human body would react to a drug containing certain molecules, or how the self-sustained oscillations in musical instruments are produced. However, and not only for the reasons discussed above, the relevance of the computer in the understanding of artistic or social phenomena is still controversial.

In recent years, and in a context not related with music, there has been a continuously growing interest in the science of complexity to understand the behavior of systems for which the classical approach of decomposition and analysis of parts fails to give satisfactory results.

In modern systems theory, complex systems are characterized by the following properties: (1) unpredictability - the system generates counterintuitive behavior that leads to surprises, (2) interdependence - there are many variables in the system and there are many feedback loops relating different variables, (3) control distribution - decisions about the behavior are not taken by one single component of the system, but by many competing components, (4) irreducibility - if the system is decomposed into isolated subsystems, then the identity of the system will be lost (5) uncomputability - any rule-following description of the behavior of the system may fail.

Systems with these characteristics show the appereance of higher-level behaviors that originate from the collective dynamics and are not found or predictable from conventional analysis of the system's constituent parts. This high-level behavior is commonly referred to as emergent behavior. For instance, a neuron is not conscious, but consciousness can be considered an emergent property of a complex network of neurons. The main challenge today in complex theory is to find mathematical laws that would explain or predict emergence behavior.

In this context, computer simulations are a precious tool. Interesting examples of computer simulations could be an artificial stock market that would study the question of which conditions would induce certain patterns of buying and selling, or a discrete lattice of gas that would give insight into the question of emergency of certain patterns of turbulence.

It can be reasonably argued that a similar approach could be applied to contemporary music in order to understand complexity. If we consider 'musicality' as an emergency property due to the interrelation of different musical parameters, then there are many questions about music complexity that can be approached by computer simulation.

Still there is the critical issue about the actual relevance of a formal approach, due to the failure of of procedural descriptions to describe both complexity of syntax and of meaning. However, it can be argued that (1) at the least, procedural approaches are very useful to describe the degree of sophistication of a music grammar. It is clear that poor musical languages will be more "artificial" and thus they will be better candidates to be represented by simpler procedural descriptions (2) if the relevant features of a musical language are extracted in a procedural description, then the emergency of 'musicality' can be studied by a computational study of a simplification of the musical language.

3. Examples.

This section presents a set of computer simulations that generate musical textures. This kind of textures are of interest among composers of contemporary music and contain features such as (1) the proliferation of events, (2) the continous transformation of material, (3) the coherence of harmonic space and (4) the structural presence of asymmetry. As can be concluded from the above introduction, the formal system that generates the textures has to fit two conditions: First, it has to be conceptually simple and perceptually relevant, so that its control remains as intuitive as possible. Second, the output of the system needs to contain some musical interest, so that it can possible to study the emergency of musicality. The implementation of the formal system has been realized with the Patchwork program. Patchwork is used to generate Midi files, and the notation is realized by manual quantification of those Midi files.. The scores have been created with the Sibelius program.

Before presenting the examples, it is worth to discuss the most primitive texture in contemporary: a sequence of notes with random pitch and duration (for purposes of simplification this discussion doesn't take into account dynamics and the timbre). This minimal system conveys total desarticulation of harmonic space (all intervals are equally possible) and total desarticulation of metric space (all durations are equally possible). The system has no memory and thus there's no hope that some degree of organization, or 'musicality' would emerge from it.

The purpose of this research can be reduced to the question of which are the effective adjustment to a minimal system in order to begin to have 'interesting' results. Example 1a and 1b illustrate a possible way to address this problem. It attempts to model a 'pointillistic' style, such as the textures that characteristically arise from serial and stochastic theories. The idea is to control the density of the events and the harmonic color and give shape to the resulting figures in such a way that conditions are given for the emergency of musicality. The control information is a list of intervals, characteristic of this type of music (minor second, major seventh, minor third, major third, tritone, and the transpositions to the octave and two octaves of these intervals), and a list of durations (different types of short and long notes). The output is computed by using three diferent kinds of random choice: pitch material, duration and direction of gesture. The algorithm works as follows: starting from an initially given pitch, the n+1 pitch is obtained from the precedent by adding or substracting an interval randomly chosen from the interval list. The decision about to add or substract is also taken randomly (in the case that the operation results in exceeding the limits of register, there is a correction and the operation is reversed). The duration of the note is obtained by a random choice on the duration list. A particular interval or duration is given more probability just by duplicating its entry in the correspondent list. In this examples, shorter durations are more probable than longer durations. A dummy zero duration is useful for generating chords. The parameters were tuned in order to achieve a close resemblance to the style. After obtaining the output, we can proceed to analyze the emergency or not of 'musicality'. The duration parameters have been tuned to obtain rhythmic gestures that are either of type accumulation-release (when several short notes preceed a longer note), or of type asymetric ostinato (when several long notes succeed each other). These gestures are characteristic of quasi-improvisatory styles and they give some life to the music.

But the most remarkable musical feature of the output is the emergency of basic macro-gestures and shapes as a consequence from the directionality variable. As this variable only has two values (up, down), random choices on it will produce patterns that eventually balance themselves, so a succession of up patterns will preceed either a succession of down patterns, or a large down pattern. This, combined with the variations and contrasts of the rhythmic figures gives a surprising sense of form to the output. Evidently, it is a form whose time span cannot stand a duration longer than 20 or 30 seconds, because of the lack of larger scale articulation in the formal system.

Example 1b is the same as example 1a but with a register limited only in the upper part of the piano, which creates with these simple means the effect of 'crystaline' sonority that is commonly searched in contemporary music.

The issue of gestural profile and harmonic coherence is addressed on a different optics by examples 2a and 2b. In this examples, the harmonic space rich in pitch content and chordal subset relationships is provided as initial dataa. The problem is how to obtain different articulations of this space that could lead to interesting textures. The harmonic space is the series of natural overtones (adjusted to the semitone) over a low C. The spectrum as a harmonic space has some interesting characteristics: it contains the 12 pitches but in an arrangement that minimizes the effect of 'dissonance'; it is composed by a strong tonal color in the low register and by a chromatic scale in the high register. It provides thus a very unified pitch space with a wealth of harmonic relations in its subsets, but at the same time all these subsets share the same virtual fundamental, so any resulting horizontal or vertical progressions will have a background of acoustical consistency.

The system that generates the excerpt shown by Example 2a is the simplest from the conceptual point of view. The goal is to find a cloud-like texture, in which there is an impression of continuous change, lack of pattern and total asymetry. The solution is to generate a succession of chords, of varying density, so it can be easily implemented with two random choices for each event, one for the number of notes in the chord, another for the notes in the chord. Higher probability is given to the notes in the higher register, to favor progressions with adjascent notes instead of the large skips in the lower part of the overtones series. The fact that this simple system can produce interesting textures comes from the mentioned consistency of chord progression due to the harmonic series.

In example 2b shows another example of emergency of organization of form and shape in a succession of gestures. A gesture is defined here as an ascending or descending succession of notes taken from the overtone series. The output is obtained by computing three simultaneous random choices: (1) the number of notes in the succession (2) the direction of the succession (ascending, descending) (3) the notes in the succession. As in example 1a, the gestures tend to have some relationships of contrast and similarity, as a series of ascending gestures will be eventually balanced by a series of descending gestures, and a short gesture will be eventually contrasted by a longer gesture. Also, the the notes that define one gesture are changing continuously, but they are all acoustically interrelated by the common fundamental, creating the effect of organization emerging from the similarity-contrast relationships.

4. Conclusions and future directions.

The ultimate validation of a music theory is a computational model on which we can experiment and test the perceptual relevance of the theory's premises. Curiously, although synthetic analysis is a standard tool in many disciplines, including sound synthesis and psychoacoustics, composers have been reluctant to this kind of approach when it comes to the issues of musicality and complexity. An intuitionistic approach to complexity in contemporary music can be useful, not only compositionally, but also theoretically, in order to address the issue of comprehensibility in contemporary music. The computational approach gives more benefit when the formal system fits two conditions (1) it is conceptually simple and perceptually relevant (2) 'musicality' emerges from its output.

The distinction between complexity of syntax and complexity of meaning is useful, but it is important to have in mind that the two concepts are interrelated - there is no meaning without some syntax, and at the same time an unknown syntax can reveal meaning after some time. Thus, it is important in the future to integrate some more of semiotics in this research. Also, it is more than necessary to integrate constraint programming, to address the issues of figure transformation and interrelation of material at different levels and to address the singular issue of timbre.

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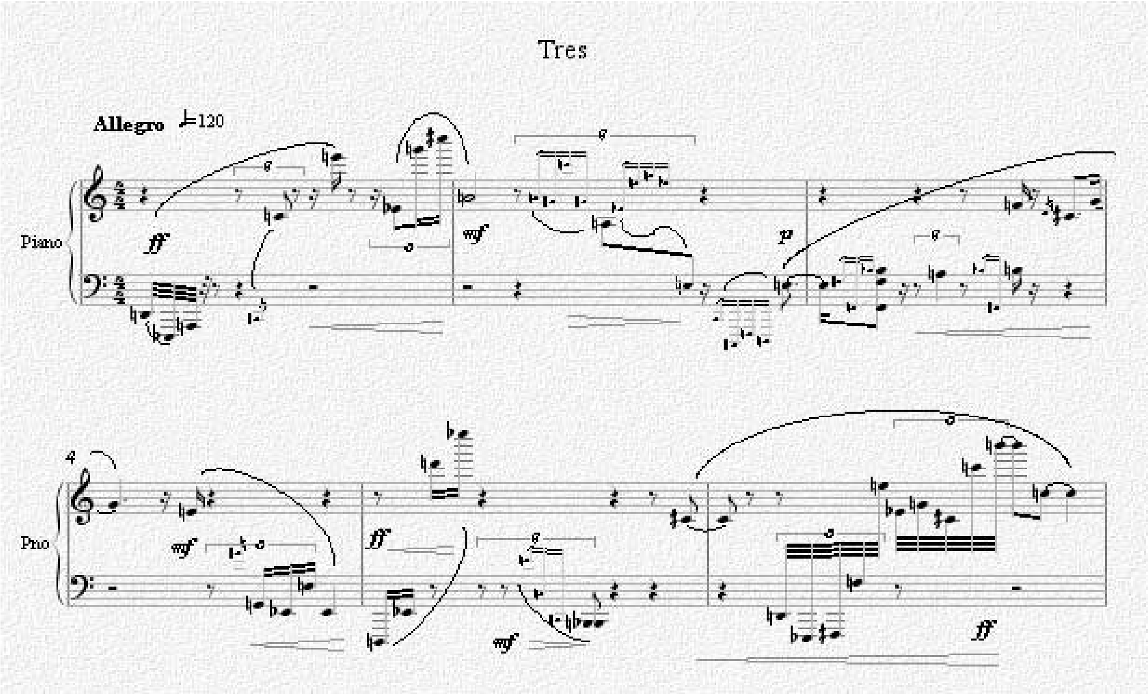
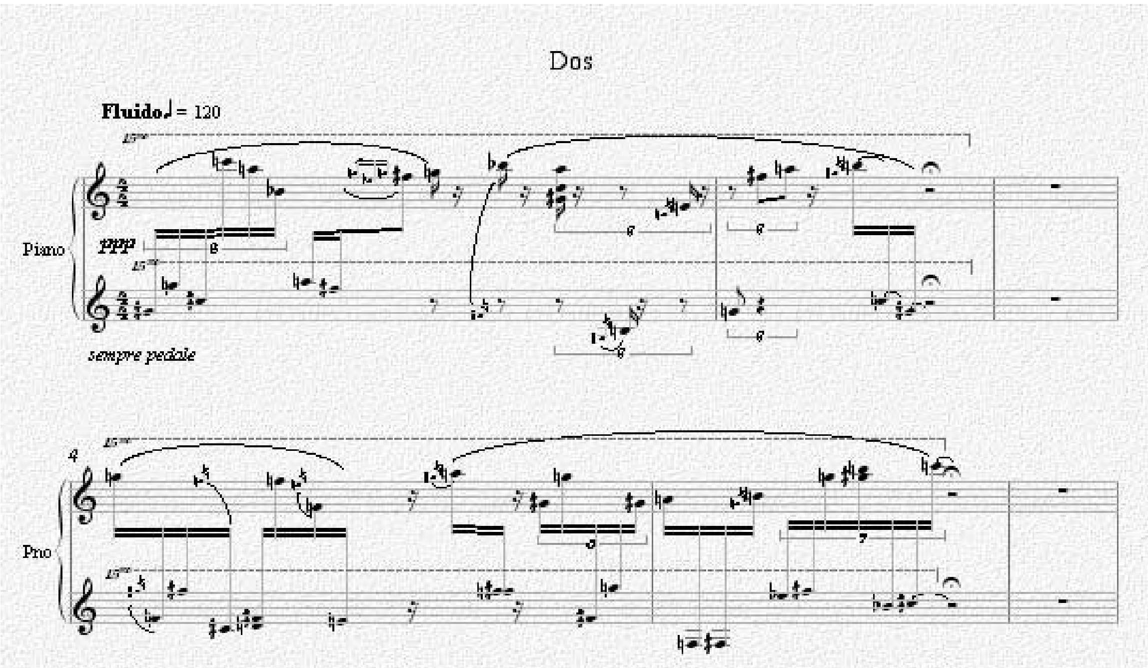
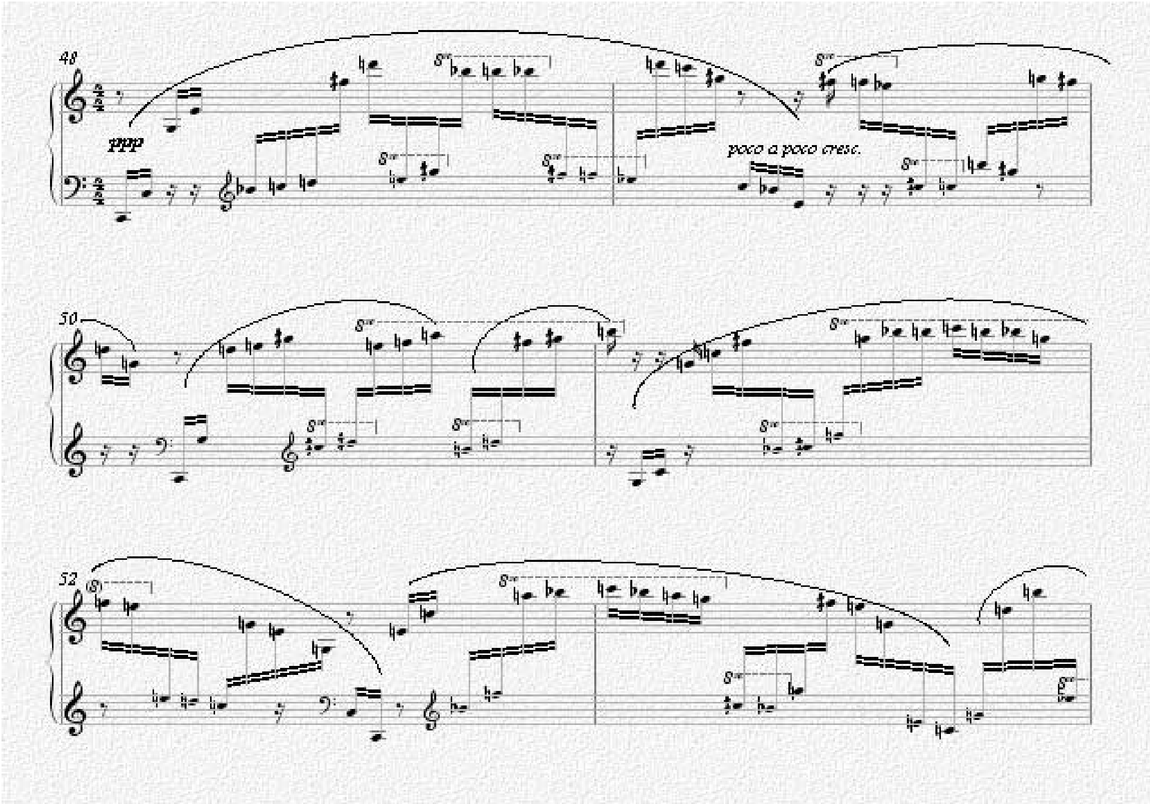
Example 1a.



Example 1b



Example 2a



Example 2b