An Evo-Devo System for Algorithmic Composition that Actually Works

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ABSTRACT

In algorithmic composition there have been countless works, using many diverse approaches, to achieve fully-automatic computer-composers. However, most of them just seem to be scattered and with no mainstream awareness or widespread use. The compositional system described here has produced a number of remarkable and original pieces, that have been premiered in live concerts, recorded by first-shelf musicians, and published as the first album made by a computer in its own, genuine style. We describe its evo-devo core, fundamented on evolutionary search of Lindenmayer systems. While the latter provides an indirect way of encoding musical pieces that imitates embryological development, the former browses the search space to find genomes that fit with requirements. The fitness function integrates formal principles of music writing, as well as general aesthetic criteria, in order to assess the quality of the final compositions. We also present some applications that derived from the particular functioning of this system, and discuss how these new fields of application might be disruptive in the music field.

Keywords

Art and music; Evolution strategies; Generative systems; Fitness evaluation; Indirect encoding

1. INTRODUCTION

The digital era has brought yet another step in the evolution of musical genres [8], as well as the development of the algorithmic composition discipline, which is at the intersection of music theory and computational intelligence. Its methods aim the automation of tasks in the creative process and it can be approached from mimicking a specific style of a set of musical examples, or by modeling the composer's methodology. While imitating existing composing styles has been done from different perspectives with relative success (e.g. [2] or [7]), creating music without an explicit reference or any human supervision represents a much harder issue. Computational creativity is a cutting-edge field, typically addressing complex and vague problems, with an ill-defined search space [3][4], hence using conventional algorithms is not feasible here.

Nature is a powerful source of inspiration for engineering and science, being called this approach Biomimetics (also Biomimicry or Bionics). In particular, bioinspired computing has yield paradigms in neural and evolutionary computation, fuzzy logic, and swarm intelligence, methods that are being applied in many fields, such as financial trade, computer vision, control systems, creative industrial design, and the arts.

We propose a compositional method based on an evolutionary algorithm with a genetic representation in the shape of a formal grammar. Particularly we use Lindenmayer Systems [5] (L-systems, for short), which are characterized by the capability of encoding relatively complex structures with simple sets of rules, and they have been previously applied in music composition (e.g. [9] or [6]).

2. THE COMPOSITIONAL SYSTEM

2.1 Indirect encoding

The genetic model comprises a deterministic L-system, plus some parameters to guide the rewriting process and the translation of the resulting string into the explicit music elements (in a similar process to the turtle interpretation).

One of the main advantages of this encoding method is its robustness. The symbols can be deleted, altered, added, or the rules be reorganized, and the representation will still be a valid form (i.e., will represent a correct musical composition); in fact, the compositions coming from a genome, and a slightly altered one, are typically very similar to each other. We demonstrated this in an exercise of musical reverse engineering, by building one possible genome of a simple, recognizable music example, the Nokia tune™, and generating a bundle of derived themes, through the alteration of the original genome (some resulting audio samples are provided[1] and Figure 1 shows how the notes and the structure were mapped).

In the set of production rules, the symbols with no rule specified for them (A→A is assumed), will act as operators in charge of managing the musical parameters (pitch, duration, onset time, effects, volume, tempo…), while on the other hand, symbols with an explicit production rule having them on the left side, will represent either structural units of the composition or specific musical notes, depending on how the grammar iterates, and they will have a musical instrument associated.

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[1] https://drive.google.com/open?id=0B9cW97LpGKeDMHI3WHJqSFdqOUk

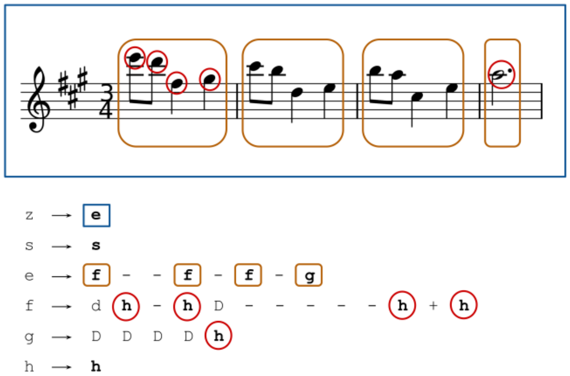

Figure 1. Illustration of the compositional structure in the reverse engineering experiment.

Table 1. Interpretation of the used genetic symbols

Symbols	Interpretation
+	Increase pitch value one step in the scale
–	Decrease pitch value one step in the scale
D	Increase duration, according to a reference
d	Decrease duration, according to a reference

2.2 Evolutionary basis

Our approach makes use of a customizable fitness function designed in collaboration with professional musicians. The generic criteria included in the assessment usually respond to ergonomic or functional aspects of the instruments, like tessituras, sweet spots or allowed effects. The rest and majority of the rules are highly conditioned by the concrete style pursued, like amount of dissonance, type of rhythm, shape of melodies, relationship among voices or use of articulations or effects. The initial population is typically filled using default templates of grammar, adding random sequences of symbols in the right side of the production rules. The new pieces will be obtained from the best rated in the previous generations, through random mutation (deletion, insertion or alteration of any symbol) of the right side of the production rules.

3. RESULTS

The produced musical content is stored in an internal structure containing also some meta-information of the process. Later, the music can be translated into the different musical standard, both symbolic (e.g. MusicXML or MIDI) and audio formats (e.g. WAV or MP3).

So far, the system has produced a huge pool of compositions in many styles, with a selection of them having been released in two albums: 0Music[2] and Iamus,[3] the later including Hello World!, arguably the first full-scale work entirely composed by a computer and using conventional music notation.[4] Some further uses of this computer generated music comprises a variety of applications based on *adaptive music* (compositions evolving in real time according to certain criteria) for different scenarios. In this line of work, the potential of music medicine has been tested in different clinical trials, such as painful procedures [10], acute stress [12], premature infants [1], or anxiety [11], proving its efficacy.

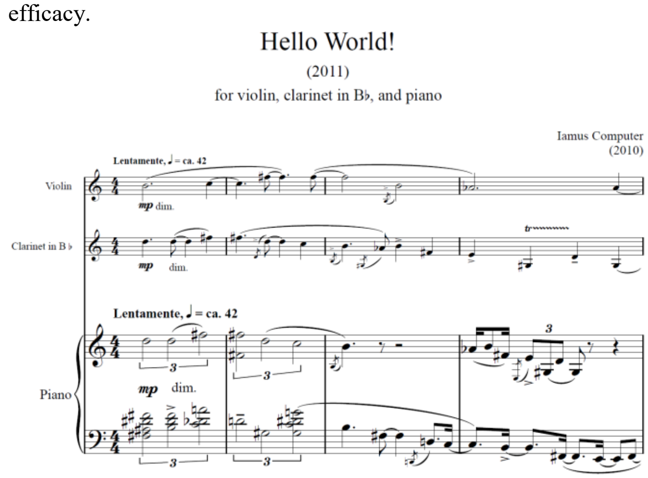

Figure 2. Score of a composition produced by the system in the contemporary classical style.

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[2] https://en.wikipedia.org/wiki/0music
[3] https://en.wikipedia.org/wiki/Iamus_(album)
[4] https://en.wikipedia.org/wiki/Hello_World!_(composition)