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The Evolution of Sound Cells. Pivot Point for the Analysis and Creation of Musical Improvisation

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Abstract

In this paper I present a new approach for computational improvisation analysis using processes from evolutionary theories. Musical phrases created by the improvisers in the course of a performance are represented as consecutive (co-)evolving sound cells, capable of producing a certain variety of sounds and structures. A corpus of recorded improvisation applied to this model can be explored and analysed in the software tool *GenIMPRO* to provide empirically informed structural data for musical metacreation using genetic algorithms.

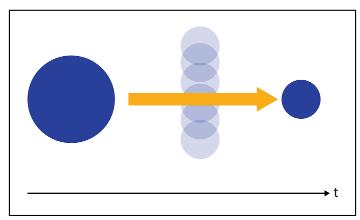
Introduction

The intersection of music and evolutionary theory is mostly viewed either from an anthropological perspective (Tomlinson 2015; Wallin, Merker, and Brown 2001), emphasising developments over long periods of time, or as an algorithmic method in automatically generated music (Miranda and Biles 2007; Manzolli et al. 1999). Recent research approaches suggest using computational methods to take a much closer look at musical evolution (Mauch et al. 2015; Serrà et al. 2012), or musical influence networks (Collins 2010).

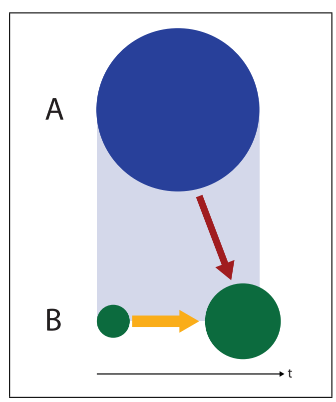
This ongoing research project takes an even closer look at evolutionary development during the duration of only a single improvisational performance. This allows following the generation and transformation of musical phrases in detail. I emphasise the interactive aspects of improvisation and refer to the concept of memetics (Dawkins 1989) to describe interchanging phrases between players in terms of evolutionary theory. The theory of memetics has already been applied to the analysis of composed music successfully (Jan 2013), but not yet to free improvisation.

Thereby, it should become possible to formalise the intersubjective activity of the memes in the form of evolving sound cells. Their sounding potential is modelled into the virtual cell's genotype by clustering over corresponding audio features in the cells' produced outcome (phenotype). The creative selection of genotypes from generation to generation can be formalised as genetic transformations, which provide data sets for structural analysis, both within and between musical improvisations.

The model provides a conceptual framework for the evolutionary development of improvisations – still an open problem in evolutionary music and art (McCormack 2005) –, which reflects the narrative power of evolutionary theory in the retrospective as well as its capability to constantly allow the emergence of new structures (Dennett 1995). With this purpose, the software toolkit *GenIMPRO* was designed, to explore and visualise improvisations and integrate their reproductive patterns into a generative system.



(a) Transformation to successive sound cell (blue circles) by mentally selecting from a population (transparent circles). Size represents duration of sound.



(b) Gene transfer (red) from player A's sound cell to coexisting sound cell of player B.

Figure 1: Visualisations of processes in the model of genetic improvisation.

Musical improvisation

Improvisation is generally considered the counterpart of composition. However, both share most aspects of musical creativity and activate the same underlying psychological processes (Nettl 1974). In the case of improvisation, the inventing and realising of musical ideas are merged together in a real-time process. Performances range within a continuum of strictly fixed scores on one side and of free improvisation on the other.

Nevertheless, improvised music is a challenge for (computational) music analysis, since it – by definition – has no reference in the form of a written score. This is especially true for "free" improvisation (meaning "referent-free" as described by Pressing (1988), i.e. without an underlying formal or stylistic scheme). Its main feature of interest in this study is the interaction between the musicians in a group improvisation. There, the implicit logic and development of musical ideas become explicitly traceable and accessible for modelling.

Evolutionary theory and genetics

Charles Darwin (1859) laid the foundation of today's evolutionary theory by formulating his concept of the "Origin of Species by Means of Natural Selection", whereby only the fittest individuals of a population survive or produce offspring and can potentially form new species by gradual transformation. Another important contribution to modern evolutionary synthesis has been made with the distinction between an outer state (*phenotype*) and an inner state (*genotype*) of the organism (Lewontin 2011). A gene can exist in different variants (*alleles*), with the sum of all the possible genotypes combined in the abstract form of the *genome*.

Model of genetic improvisation

The following model of genetic improvisation describes the processes during a musical improvisation through the evolution of sound cells. Like evolutionary theory, it can point in opposite directions: on the one hand retrospectively, towards the analysis of finished improvisations, and on the other hand as an algorithm (Dennett 1995), unfolding its generative potential towards the future. Thus, the model can function as an interface between musical analysis and metacreation.

Generative perspective

While gaining an insight into the emergence of structures in improvisation is the main rationale for using this model as an analytical tool, we first look at genetic improvisation from the algorithmic perspective to see its general principles.

(1) An improvisation is created through successive sound cells as the individual in an evolutionary process. Each sound cell lives only for the duration of its sounding and holds a specific musical potential, limited by the "field of possibilities" (Eco 1989, 103) of its genotype. A sound cell can be understood as a musical micro-instrument that retains only one possible phenotype in its actually yielded sonic *gestalt*.

(2) The subsequent sound cell arises as an uniparental clone and is transformed by a mental selection process (Johnson-Laird 2002) between different mutations of genotypes (following Dawkin's (1989) concept of the gene as the object of selection) until the most appropriate sound cell is realised in sound (see fig.1a). This results in a unique lineage of sound cell generations, representing an ideal evolutionary line. The actual selection process though is hidden in the player's mind.

(3) If more than one player improvises, the sound cells from all the improvising players develop in co-evolution. Genetic material can be exchanged (gene transfer), which can thereby enable rapid development between simultaneously living sound cells (see fig.1b). This allows for interaction and synchronisation on different musical levels (e.g. harmonically, melodically, rhythmically, etc.).

Analysis methodology

In order to analyse the inner genetics of a corpus of improvisations, all recorded tracks are split into short phrases by identifying the silent regions of adaptive length in between the phrases. The retained audio sections become individual sound cells with their phenotypes computed using MIR (Music Information Retrieval) methods. Genes are then formed by clustering for different alleles in subsets of the phenotype descriptor space. The combination of all genes builds the genome for the whole analysed corpus.

GenIMPRO

The analysis methodology presented above is implemented in the open source software tool *GenIMPRO*[1] which is still in the early stage of development. Its first module consists of a set of python scripts for the pre-processing and analysis of the audio recordings. Furthermore, it facilitates interactive visualisation (using the dynamic data visualisation library D3 (Heer, Ogievetsky, and Jeffrey 2011)) to explore the analysis' outcome (see fig.2). This second element was included to improve the overall interpretability of the model and thus to provide a more musically meaningful representation by e.g. labelling the alleles of genes for their musical qualities.

As a third module, it is intended to implement the genetics of the improvisations as an evolutionary algorithm that mimics the transformational behaviour and selection by the fitness of certain genotypes. A server application can receive real time analysis values via OSC (Open Sound Control), generate subsequent sound cells and send their genotype data back to sound synthesis or processing applications, such as Max/MSP, Supercollider, etc. to generate new musical sounds and structures. This distinction between phenotypic appearance and genetic properties leads to a metagenerative system, evolving novel inner structures but leaving their realisation up to another system.

[1] `https://github.com/bastustrump/genimpro`

Figure 2: Screenshot of GenIMPRO interactive visualisation with an improvisation of two players and phenotype/genotype bar charts of a selected sound cell. Additionally, genotypic relations between sound cells are visualised as connection lines.

Conclusions and future work

This paper introduced a new model for the computational analysis of musical improvisation and generation using evolutionary theories. While the analytical part is already implemented and producing promising results, the generative part is still an open issues. Applicable algorithms have to be found and evaluated in the context of artificial music generation systems.

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