The development of musical styles in a society of software agents

Marcelo Gimenes **Eduardo R Miranda** **Chris Johnson**
Interdisciplinary Centre for Computer Music Research, Faculty of Technology
University of Plymouth, United Kingdom
{marcelo.gimenes, eduardo.miranda, c.johnson}@plymouth.ac.uk

ABSTRACT
The purpose of this paper is to give a general overview of the computer system that we are developing at the University of Plymouth to simulate the evolution of musical styles in societies inhabited by software agents. It is mostly inspired in real world human beings' musical abilities and activities and is designed to investigate possible alternative routes to the history of the evolution of musical styles under the viewpoint of musical interactions and influences.

Keywords
Music style evolution, computational model, memetics.

INTRODUCTION
When we are born, we are presented with a very complex cultural heritage as old as history itself and as we grow old we quickly absorb huge amounts of all sorts of information. Only in a few cases though we are able to identify the origins of this inheritance, the ones we are exactly succeeding to.

To better clarify our point, when we look at an "original" piece of music, we know that, in spite of the fact that there may be a high degree of creativity involved, the embedded raw material used to build it up is in fact in great part a consequence of one's cultural inheritance, or of all musical material absorbed during one's lifetime. In other words, composers tend to replicate in their choices what was learnt from the environment that surrounds them.

Actually, all pieces of music have a great deal to say about themselves and about their creator's history of influences. Musicologists have long been seeking to find out connections between this and that work in order to establish from where certain types of musical materials could have been originated. After all, the process of compiling and recompiling musical material is nothing less than the process of musical evolution itself.

Therefore, when we listen to a piece of music we are appreciating no only the composer's own musical worldview but also what the composer musical heritage was like. Although succession lines can sometimes be disguised, invariably a piece of music displays a distinct balance between its musical elements and structures. This balance is dictated by the relevance that each one of these musical structures have in the composer's worldview and results ultimately from how each and all the music the composer previously had contact with.

It is significant to say that we are not referring to all sorts of music here. To take an example, in contemporary music composers commonly use very complex algorithms that end by emerging an outcome that is not easy to foresee. In these cases composers do not have direct control over the composition itself but rather over the processes that will result in the composition.

Composers such as Cope (1991), Dodge (1985), Worral (2001) and Xenakis (1971) have used mathematical models such as combinatorial systems, formal grammars, probabilities and fractals to create new pieces of music. Others have used Genetic Algorithm procedures for evolving musical materials such as melodies, rhythms and chords. One such example is the system Vox Populi (Manzollli, 2000), which evolves populations of chords of four notes, through operations of crossover and mutation.

Evolutionary Computation models are also being used in many models. In one of them, CAMUS (Miranda 1993), the emergent behaviour of Cellular Automata (CA) is used to generate musical compositions in which case the coordinates of the cells are associated with the distances between the notes of a set of three musical notes.

The scenario that we are describing in this paper would probably not fit well in the above-mentioned cases. In fact, we are focusing on the type of creative work that is usually associated with a more traditional composer, of the type that has straight control over the outcome by mentally conceiving musical structures and putting them onto the score afterwards.

An even better case perhaps could be found in the performer/improviser paradigm which, as much as the traditional composer, also have direct control over their work

but doesn't use the eraser to reject some "not so desired" ideas. They rather give the materials new significance with new ideas that are produced thereafter. This characteristic allows for the observation, during an improvisation session, of immediate responses to musical propositions. As a result, the listener can stay much closer to what could be considered one's musical worldview.

Having introduced the general background in which our research is centred, in the next sections of this paper we give a brief overview of the model we are proposing - destined to experiment with different music style evolution possibilities - and describe some of its core components. Some definitions will be explored along with pinpoints on the research that has already been done in the area and some of the solutions that are currently being implemented.

THE MODEL: AN OVERVIEW

A growing number of researchers are developing computer models to study cultural evolution, including musical evolution (Blackmore, 1999). For instance, Miranda (2002) investigates how musical structures can originate and evolve in artificially created environments and inhabited by virtual communities of musicians and listeners.

Impett (2001) uses an Agent system to generate musical compositions. Through the interaction of embodied behaviours that co-exist and interact in the same world, Agents are adaptive to the changing environment to which they belong.

In our system (the "System"), autonomous agents (Maes, 1991) inhabit an artificial environment where they sense and act autonomously executing a series of goals. Their basic drive is to look for the existence of music compositions and to interact with them in order to develop their own musical worldview. When they are "born" their musical knowledge is "empty" but they naturally possess certain abilities and skills to execute basic tasks such as listening, segmenting and storing music into their musical worldview. Besides, Agents are also able to generate new music, again, based on their musical worldview.

At this point, it is important to have a more precise definition to the expression "musical worldview" (or "musical knowledge") and understand how it applies to the context of style evolution. According to Park (2002), worldview is "the collective interpretation of and response to the natural and cultural environments in which a group of people lives. Their assumptions about those environments and the values derived from those assumptions."

Through their worldview people are connected to the world, absorbing and exercising influence, communicating and interacting with it. Hence, a "musical worldview" is a two-way route that connects the individual with its musical environment. On one side, individuals receive influence through activities such as listening to and practicing music, which end by building up their perception of the musical world. On the other side, departing from this perception, they exercise influence through activities such as performing and composing music.

The mechanisms that comprise the perception of the reality, the emergence of "beliefs" (musical worldview) and the response to the external world in the form of influence are obviously very complex. In the System though we defined some general procedures through which Agents can evolve musical worldviews in a more simplified way. These procedures will be addressed in the sections below.

SOME CORE CONCEPTS

For our research on "style evolution", the definition of style proposed by Meyer (1989) is a good starting point: "a replication of patterning, whether in human behaviour or in the artefacts produced by human behaviour, that results from a series of choices made within some set of constraints". Some fundamental elements arise from this statement:

"A replication of patterning"

English mathematician and philosopher Alfred North Whitehead (1954) once declared: "art is the imposing of a pattern on experience, and our aesthetic enjoyment is recognition of the pattern." Patterning implies the sensitive perception of the world and its categorisation into forms and classes of forms through cognitive activity, "the mental action or process of acquiring knowledge and understanding through thought, experience and the senses" (Oxford Dictionary).

Musicologists have addressed this issue in a number of different ways, starting from simple elements such as notes and chords and going to more structural concepts that define the overall form of a piece of music. In the middle way, researches look at "semantic units" (Boroda, 1992), which embody "a kind of musical molecule consisting of a number of integrated musical events, possessing a certain completeness, and well adapted to combination with other similar units." (Schoenberg, 1983, pp. 3-8, cited in Boroda, 1992). Mazel (1967, cited in Boroda, 1992) calls these structures motifs: "A motif is the smallest part of a musical idea which is both meaningful (expressive) and constructive".

Lately, the term "meme" was introduced by Dawkins (1991) to describe basic units of cultural transmission in the same way that genes, in biology, are units of genetic information. "Examples of memes are tunes, catch-phrases, clothes fashions, ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperm and eggs, so memes propagate in the meme pool by leaping from brain to brain via a process which, in the broad sense, can be called imitation." (Dawkins, 1989, p. 206)

The idea of employing this expression is attractive because it covers at the same time the concept of structural elements and processes of cultural evolution, something that fits into the purpose of our research. For this reason we shall adopt the term "musical Meme" or simply "Meme" to refer to

musical structures in the System. However, note that we do not subscribe to all aspects of the original memetic theory, as we believe that it needs to be expanded and/or adapted for our purposes.

In the System a Meme is defined as the shortest possible musical structure that cannot be segmented without loosing musical meaning. Hence, Memes are generally small structures in the time dimension although they can have any number of notes vertically.

The system also defines that each Meme has equivalent meta representations, referred to as Meta Equivalents. Each Meta Equivalent corresponds to a musical feature of the Meme, such as melody movement, texture, density, rhythm, etc. It is the combination of all Meta Equivalents that describes a Meme. The difference amongst Memes is calculated by measuring the distances between the Meta Equivalents. In addition, Meta Equivalents also serve as raw material for the generation of new Memes for new pieces.

Human behaviour and choices

The second fundamental element that arises from Meyers' definition is the fact that style is intimately connected with human behaviours and choices.

So far we have referred to the musical style as a human activity although there can be different styles "in the artefacts produced by human behaviour" (Meyer, 1989). Examples of this type of style can be found in the work by Cope, Xenakis and Miranda, as previously mentioned.

Our research, however, is committed to the investigation of music as a process in which musical structures are first conceived in the composer's mind and then transferred to the score or played by a performer/improviser.

Constraints

Finally, again taken from Meyer's definition on style, is the fact that many sorts of constraints - that are ultimately determined by the environment in which the composer dwells - condition the arrival and disappearance of different musical styles. In particular, culture background and technological means of musical realization are essential to understand the existence and feasibility of styles.

Without going too much further into this field, it is worth mentioning only that, due to the current state of the art in information technology, especially in the age of the Internet, we are tempted to say that these constraints could be bound to disappear. Are we really heading towards a global musical style?

MUSIC INTERACTION AND THE EVOLUTION OF MUSIC STYLES

The System defines that every time Agents interact with a piece of music their musical knowledge changes according to the similarities and/or differences that exist between this piece and their musical knowledge. This analysis is done in a Meme by Meme basis by comparing pairs of Memes according to their Meta characteristics as described above (melody movement, texture, density, rhythm, etc.). At any given time, each Meta Equivalent for each one of the Memes in an Agent's worldview is assigned with a weight that represents their relative importance in comparison with the corresponding Meta Equivalent in the other Memes.

The adaptation mechanism is fairly basic: these weights are increased as a consequence of the number of times each Meme is listened to by an Agent. The more an Agent listens to a Meme, the more its weights increase. Conversely, if a Meme is not listened to, its weights are decreased and, in other words, the Agent begins to 'forget' it.

This system of adaptation has somehow already been object of study in broad terms in the Memetics theory. Cox (2001) asserts that the "memetic hypothesis" is based on the concept that the understanding that someone has on sounds comes from the comparison with the sounds already produced by this person. The process of comparison involves tacit imitation, or memetic participation that is based on the previous personal experience on the production of the sound.

According to Jan (2000) "the evolution of music occurs because of the differential selection and replication of mutant memes within idioms and dialects. Slowly and incrementally, these mutations alter the memetic configuration of the dialect they constitute. Whilst gradualistic, this process eventually leads to fundamental changes in the profile of the dialect and, ultimately, to seismic shifts in the overarching principles of musical organization, the rules, propagated within several dialects."

Agents in the System are also able to compose by a process of re-synthesis of the different Meta Equivalents of the Memes in the worldview of an Agent into new rearrangements of Memes. Obviously, the selection of the Memes that will be used in a new composition implies that the musical worldview of this Agent will also be re-adapted by reinforcing the weights of the Memes that were chosen.

Memetic theorists have also foreseen these possibilities. Gabora (1997) explains that, in the same way that information patterns evolve through biological processes, mental representation, or memes, evolves through the adaptive exploration and transformation of an informational space through variation, selection and transmission. Our minds perform tasks on its replication through an aptitude landscape that reflects internal movements and a worldview that is continuously being updated through the renovation of memes.

Eventually, the evolution of the musical styles can be measured directly by looking at the different configurations of weights presented by the Memes in the Agents' musical worldview alongside their career. Obviously, this is not possible to achieve in the real world simply because one cannot look inside the brain and figure out any type of Meme or musical style.

We would normally look at the most visible outcome of a musical worldview, which is the musical output (or "score") itself, in our case, the compositions delivered by the Agents. It follows that - having in mind the Hierarchy of Style described by Jan (2000) - it is possible to obtain a measure of distance and/or similarity between the styles of two different compositions by considering the different weights that each Meme have in these compositions (intraopus style). The same logics can be applied to compare the musical style in different levels of the Hierarchy (idiom, dialect, etc.).

THE SYSTEM IN ACTION

We have previously published a paper introducing a first prototype of the System, in which Agents only dealt with rhythm information (Gimenes, 2005). The current implementation basically follows the same general concept.

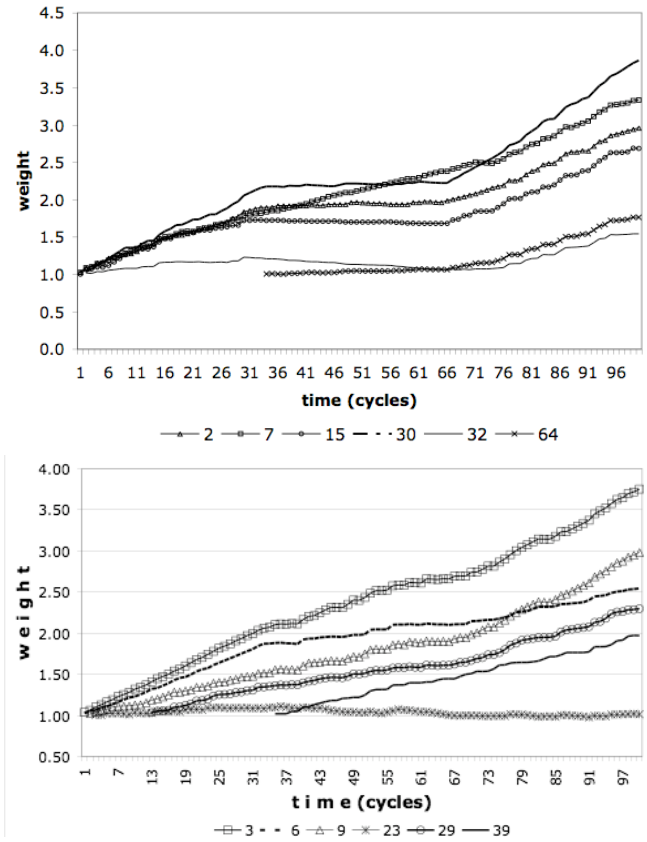
The user of the System can define scenarios for the observation of the evolution of musical styles by creating a number of Agents that will interact with music. A set of compositions is provided so that Agents have initial material to interact with. They are given a number of tasks (listening, practicing and/or composing) and the criteria (genre, date of composition, name of composer, etc.) they will apply to choose the compositions with which they will interact.

Once a piece of music is chosen for a listening or a practicing task, it is segmented into Memes that will then be compared with the Memes already present in the Agents' musical worldview. This results in the alteration of the weights of the several Meta Equivalents of each Meme, as explained above. If the current task is to compose a piece of music, the Agent chooses a series of Memes according with the weights of their Meta Equivalents.

The user of the System can define that Agents choose pieces composed by themselves and/or by the other Agents that inhabit in the same environment. In this case, the System is independent of further interventions by the user and is able to generate its own musical material that produces the next generation of musical styles.

The next graphs (Figures 1 and 2) show one of the approaches that can be used to evaluate the musical style evolution in the System. They represent two different simulations in which one Agent received the same number of listening tasks but different criteria to evaluate the music with which to interact. The music (or sets of pieces) chosen at each interaction was, therefore, different. Each line in the graph represents the evolution of the weights of the rhythmic Meta Equivalent of a selection of Memes that were present in the Agent's musical worldview.

By observing the behaviour of these curves we can already draw some conclusions regarding the relative importance of each one of the Memes during the evolution of the musical worldview of the Agent.



Figures 1 and 2. Rhythm evolution of a selection of Memes in two different simulations.

Some of these Memes, in spite of appearing only later in the simulation, at the end are stronger than others that appear at the very beginning. Some have a steady linear growth comparing to others that have a more instable behaviour. This is probably due to the fact that these Memes have a better distribution throughout the pieces that were chosen by the Agent.

CONCLUSION

In this paper we introduced a System that is being developed at the University of Plymouth in which autonomous agents interact with music compositions in order to develop their own musical worldview. We aim to investigate the history of the evolution of musical styles under the viewpoint of musical interactions and influences.

Since this is an ongoing project some of the features of the System, such as the appropriate treatment to be given to the data collected from the simulations, are still being addressed.

This report covers, for the most part, the theoretical background of the subject. Some of the details of the technical implementation were intentionally left out because they are beyond the scope of this paper.

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