Proceedings of the 23rd IASTED International Multi-Conference
ARTIFICIAL INTELLIGENCE AND APPLICATIONS
February 14-16, 2005, Innsbruck, Austria

Genetic Approaches for Evolving Form in Musical Composition

Aladdin Ayesh and Andrew Hugill
De Montfort University
The Gateway, Leicester
LE1 9BH
UK
{aayesh, ahugill}@dmu.ac.uk

ABSTRACT
An approach of evolving form in musical composition is presented here. The use of genetic algorithms in musical composition is not new but rather energetically active field of research and experiments. However, the approach presented within this paper differs from other genetic composition approaches in twofold. First, samples of musical ideas (one note or more) and not individual MIDI notes are used. Second, the focus of the approach is on evolving musical form rather than attempting to compose musical sequences. In addition, the selection process is guided by the responses of the users within an interactive process. In this paper, a genetic algorithm (evolving musical form algorithm (EMFA)) is presented in details followed by a brief examination of a sketched prototype of the system.

KEY WORDS
Modelling, genetic algorithms, simulation, automated compositions, and evolutionary music

1. Introduction

The use of genetic algorithms in musical composition is an energetic and active field of research and experiments. Many of the approaches presented within this field [1] attempt to devise genetic algorithms that are capable of composing music autonomously. It is a habitual requirement to start from individual musical notes to build sequences or musical ideas. MIDI language is often the choice of musical representation in these approaches.

Considering the results of most genetic algorithms compositions, there seem to be two philosophical standpoints in analyzing these results. There is what one may call the traditional or human music school that attempts to make the computer imitate the human process of composing music [2] and [3]. It relies heavily on the composition rules presented in music theory books. Music composition in this case becomes almost a constraint satisfaction problem. Often, the resulting compositions are disappointingly a stereotype of previous examples. Creativity seems to be heavily constrained if not absent in this approach.

The other school, which one may call the computer music school, attempts to enable the computer to compose its own music [4]. The results in this case are often strange and to some degree unpleasant making it difficult for an audience to listen.

In this paper, a genetic algorithms based approach is presented to stand in between the two schools. The approach presented within this paper differs from other genetic composition approaches in two respects. First, samples of musical ideas, which consist of more than one note, are used in the place of individual notes. These ideas as we will see are divided into five different groups. Each group has its own musical characteristics. Second, the focus of the approach is on evolving musical form rather than on attempting to compose musical sequences.

It is clear that this approach depends on a human input in the composition process starting with the musical ideas, i.e. the samples, provided. The interactive process includes the listener as well as the composer in the evolving compositions through the fitness function and selection process. In addition, the fitness function is assisted by the responses of the users within an interactive process. In this paper, evolving musical form algorithm (EMFA) is presented in details followed by a brief examination of a sketched prototype of the system.

1 Background

The work of Fels and Manzolli [2] presents the closest of evolutionary approaches literature to the work presented here. However, the attempts to develop interactive musical systems [5] and evolving musical components [6] show a growing recognition of the importance of interaction between the system and the composer, performer and listener. In this section, a brief background analysis is provided for the most relevant works found in the literature in relation to the work presented here. In addition, a conceptual discussion of musical forms is presented with an explanation of what is meant by 'evolving form'.

1.1 Genetic Algorithms in Music

Genetic algorithms have been used in art generally [7] and in music particularly [1] for sometime now with various degrees of success. As music concerned, there are general features that summarize the use of genetic algorithms. First, most of the attempts made use some form of representational language such as MIDI [2] to represent the musical notes with rules to compose [4]. The genetic algorithms are used in these cases to satisfy these rules and generate a composition. As the result of unsupervised musical composition systems are often musically unsatisfactory, attempts are being made to enable the user to interact with these systems [5] and [2].

In this paper, we build upon these advances and enable greater interactivity between the system and its users. We identify two types of users: the composer and the listener. These two groups would need to interact with the system. The composer helps the system to compose by providing pre-composed musical ideas. The listener controls the direction in which these musical ideas may be deployed. Such cooperative interaction between the composer, the listener and the composition process has not been enabled in this way previously neither in traditional nor in computer-based compositions.

1.2 Evolving Music Form (EMF)

Evolving music form is a treatment of the musical form inspired by the biological process of evolving. Looking at the music ideas as cells or elements within cells, these ideas may grow, merge and de-merge in different ways creating a population of ideas. The concept of EMF has started from compositional ideas the composer co-author of this paper had on changing musical form. This changing musical form is based on short colour-coded musical ideas and affected by the input presented by the user. In some ways, this input similar to the selection function used in genetic algorithms, while the short musical ideas are similar to genes. The only work that is very close in concept to this work is [8]. McCormack attempts to devise a sonic ecosystem that evolves. EMF provides evolving formation of the musical ideas.

2 Evolving Musical Form Algorithm (EMFA)

A genetic algorithm (algorithm 1) has been devised to enable evolving musical forms from given set of categorized samples (primary chromosomes) and set of rules encoded in these primary chromosomes. The result of the algorithm is a set of solutions, i.e. ordered samples in a musical form, which are encoded as secondary chromosomes.

Algorithm 1 EMFA

1. Select primary chromosomes (PC) from five colour-coded genes pools into five colour-coded arrays. The number of PC is guided by the user input.
2. Apply fitness function '*evaluate*' and select function '*norm*' to the selected PC to produce a normalized set of PC.
3. If the user select number of evolutionary cycles (NoEC) = 0 then return the normalized set of PC as a solution;
4. If the user select NoEC >0 number of evolutionary cycles then
5. While User-NoEC > Actual-NoEC
   a. Apply the requested evolutionary operators, i.e. crossover and/or mutation, to produce new population.
   b. Apply fitness function '*evaluate*' and select function '*norm*' to select the new population to enter the next cycle of evolution.
6. Repeat until User-NoEC = Actual-NoEC
7. Produce final solution for the user to indicate satisfaction.

2.1 Geno-coding

A system of five colour-coded type groups of musical ideas is devised to enable evolving forms. These colour-coded groups are: blue, violet, magenta, purple, and red. Each type has its own characteristics in terms of dynamics, timbre, and modality (Table 1).

	Dynamics	Timbre	Modality
Blue	*p*	Wind, strings	Phrygian C sharp
Violet	*mp*	Wind, strings, brass	Phrygian C sharp -> Ionian A
Magenta	*mf*	Wind, strings, brass, percussion	Ionian A
Purple	*f*	Wind, brass, percussion	Ionian A -> Dorian F sharp
Red	*ff*	Brass, percussion	Dorian F sharp

Table 1. Musical ideas characteristics: dynamics, timbre and modality

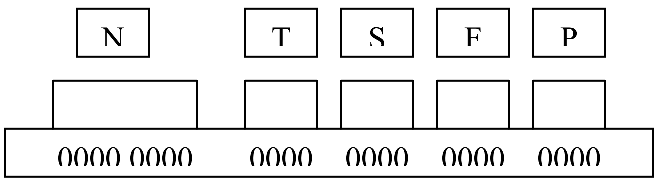
In addition, each type has musical characteristics in terms of melody, harmony, countermelody and rhythm (Table 2).

	Melody	Harmony	Counter-melody	Rhythm
Blue	Very strong (4), decorated	Silent (0)	Silent (0)	Weak (1)

Violet	Strong (3), lightly decorated	Weak (1),	Weak (1)	Silent (0)
Magenta	Average (2), undecorated	Very strong (4)	Average (2)	Average (2)
Purple	Weak (1)	Average (2)	Very strong (4)	Strong (3)
Red	Silent (0)	Strong (3)	Strong (3)	Very strong (4)

Table2. Musical ideas characteristics: melody, harmony, countermelody and rhythm.

These five groups are the five types of chromosomes used in the evolutionary algorithm to produce musical sequences. Each sample or primary chromosome is represented as a sequence of bits



N: is the number of the chromosome in its respective pool

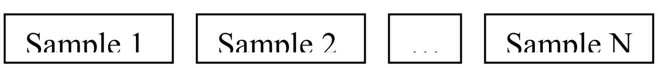
T: is the type of the chromosome

S: is the strength

F: indicates which type would the chromosome follow.

P: indicates which type would the chromosome precede.

Each secondary chromosome is represented as an array of samples in a sequence.



It clearly that we would have two types of secondary chromosomes (SC) that are mono-SC, which are often appear in the first cycle of the evolutionary process, and the chromatic-SC, which are expected in the results of the evolutionary cycles. For practical reasons we limit SC to 6 samples only.

2.2 Operators

Two operators are used: crossover and mutation. Crossover operator work on SC by splitting two SC at the middle and substitute the upper half of each SC with the lower half of the other SC.

The mutation operator has two modes. The closed mode means that the operator will mutate a given SC (X) by replacing one of the samples in X with a randomly selected sample from the current population. The replaced sample as a result will vanish from the current population, which is in effect reduced. The closed mode mutation affects the geno-graphic distribution of the primary chromosomes (PC).

The open mode will result in replacing one of the samples in X with a randomly selected sample from the genetic pools available in the system. That leads to a change in the geno-graphic composition of the population.

2.3 Fitness Function and selection

Two functions are used '*evaluate*' and '*norm*'. '*Evaluate*' (E) is the fitness function that evaluates SC based on their PC.

$$E(SC) = \sum_{j=0}^{n} S(PC_j) + F(PC_j, PC_{j-1}) + P(PC_j, PC_{j+1})$$

There are three evaluation factors that are the strength of a given PC (S) and the relation between the given PC and its predecessor (F) and successor (P). '*Norm*' (N) is the select function. There are three polymorphismic versions of N. The first version of N applies at the initialization stage of the evolutionary process is to normalize the selected number of colour-coded samples into their respective mono-SC of 6 samples each as a maximum.

The second version of N is to select the SC, which will survive to the next evolutionary cycle. In this version the number of SC will be reduced to the 5 most fit SC's unless there are two SC's which have the same fitness level as indicated by E function. In that case, both SC's will be added to the population as long as they are not the same. In other words, they do not contain the same samples in the same order.

The third version of N selects the final result using E function to determine the most fit of results. If there are two SC with equivalent fitness a secondary evaluation function would be applied based on the relationships between the samples:

$$N_e(SC) = \sum_{j=0}^{n} F(PC_j, PC_{j-1}) + P(PC_j, PC_{j+1})$$

3 Implementation

A prototype of the system is currently being developed using Java. The choice of the language was dictated by the fact that this system will eventually be deployed on the Internet. The current prototype focuses on the interface requirements; therefore it assumes a single user. Figure 1 shows the main screen.

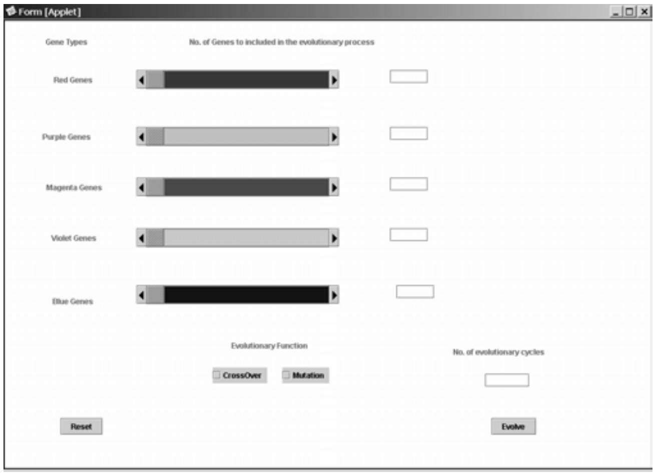


Figure 1: System Interface with colour-coded musical ideas.

The slides are used to allow greater interactivity through representing the five colour-coded genetic pools with matching coloured-slides.

4 Conclusion

In this paper, an interactive system of evolving musical forms has been presented. This system uses samples of musical ideas instead MIDI notes. The interactive process provides the user with a control over the directions into which these musical ideas are deployed. A prototype that is being implemented has been discussed. Trails of the prototype are on going. Future work will aim to:

- Complete user evaluation interface and integrate that in the evolutionary process.
- Enhance the selection by providing gene strength and the use of genetic dominance.
- Enable multi-user environment and user profiling for repeated visits. Also allow feedback from previous populations and evolutions into new evolutionary cycles.
- Provide visual interpretation of the results.

References

[1] G. Wiggins, G. Papadopoulos, S. Phon-Amnuaisuk and A. Tuson. "Evolutionary methods for musical composition." *CASYS98 Workshop on Anticipation, Music & Cognition*, 1998.

[2] S. Fels and J. Manzolli. "Interactive, Evolutionary Textured Sound Composition.", Available from "citeseer.nj.nec.com/534239.html".

[3] J. Biles. "GenJam: A genetic algorithm for generating jazz solos." *ICMC Proceedings*, The Computer Music Association, 1994.

[4] J. McCormack. "Grammar Based Music Composition.", Avaliable from "citeseer.nj.nec.com/521113.html".

[5] B. Johanson and R. Pol. "{GP}-Music: An Interactive Genetic Programming System for Music Generation with Automated Fitness Raters." *Genetic Programming 1998: Proceedings of the Third Annual Conference*, 181-186, 1998.

[6] S. Phon-Amnuaisuk, A. Tuson and G. Wiggins. "Evolving Musical Harmonisation.", Avaliable from "citeseer.nj.nec.com/446396.html".

[7] J. McCormack and A. Dorin. "Art, Emergence, and the Computational Sublime.", Available from "citeseer.nj.nec.com/507870.html".

[8] J. McCormack. "Evolving Sonic Ecosystems.", Preprint, available from "citeseer.nj.nec.com/544723.html". 2003.