Composing Music Using Genetic Algorithms

Kathiravelu Ganeshan
UNITEC
Auckland, New Zealand
kganeshan@unitec.ac.nz

Jonathan Pickard
Xavier University
Cincinnati, Ohio, USA
JPickard@cinci.rr.com

In this paper, we describe the use of genetic algorithms in composing original music in an evolutionary fashion. We also discuss plans to use the music in smart houses and in music therapy.
The music is evolved starting with any given subset of the twelve musical notes. The compositions grow in duration with every generation.
In the current version of the software, the fitness of any generation is determined by a human listener. In future versions, the fitness may also be decided by a fitness algorithm that compares the musical pleasantness of the composition with musical landscapes on various genres of music.
The output from this software, which is a single melody, can then be used as input to the music rendering software that is being developed by the first-named author, thus generating original music complete with percussion as well as all the harmonies of western music or the special nuances of other genres of music, particularly the *gamakams* of Indian *raagas*. Using this software with evolving technologies in the area of robotics, multimedia entertainment systems with real 3-D action can be realized. Making use of evolving sensor and smart house technologies this software can also become the backbone of an intelligent music composition system that can generate original music to suit and/or alter the mood of the occupants of any room in a smart building.

1. MUSIC

All music is vibration. Pitch as we hear is the effect of our eardrums being made to vibrate at some frequency. Timbre of any instrument is a combination of several vibrations at frequencies that are characteristic of that instrument. Rhythm is also a frequency – the frequency of the beats. From this perspective it is possible to view automating composition as the production of vibrations at one or more frequencies at various points in time. Electronic music is often produced this way and can be automatically composed relatively easily. However, from the time of Pythagoras or perhaps even before that, we humans are attuned to things such as consonant intervals, dissonant intervals and cadences (Gaffurio, F, 1492, quoted in Lawler, Robert 1982) and this makes the composition of music that will be considered to be good music by at least a few people other than the composer, a difficult task.

2. MUSIC COMPOSITION

Composers use several techniques to compose new music. They may look for that spark of inspiration by humming a tune, listening to other people's compositions, sitting at the beach and listening to the waves, or, walking in the woods and listening to the wind, the birds and the bees. They may also use one of several computer aided composition programs or use the musical parameters approach, in which the composer composes the music by defining each of the musical parameters, such as pitch, rhythm, timbre, and dynamics. The last mentioned approach has great appeal from a computing angle as it is not hard to imagine writing algorithms that can define each of these parameters based on a set of rules. Another approach to music composition is evolution.

3. EVOLUTION

According to Darwin's theory of evolution, all living things evolved from single cell organisms. Drawing a parallel, we decided to evolve our music from single notes. Darwin's theory has recently been challenged by Illinois microbiologist Carl Woese (2002) in the June 18 issue of the Proceedings of the National Academy of Sciences. According to Woese, "there were initially at least three simple types of loosely constructed cellular organizations. They swam in a pool of genes, evolving in a communal way that aided one another in bootstrapping into the three

distinct types of cells by sharing their evolutionary inventions".

4. EVOLVE THE MUSIC FROM A CONTINUOUSLY VARIABLE PITCH OR A SET OF DISCRETE PITCHES?

Music, regardless of genre, is a combination of sounds of different pitches, durations, loudness, timbre and other parameters. Music can be produced by varying the pitch and loudness of the output of electronic instruments such as a Theremin. The variation of the pitch here is analogue. Such analogue variation of pitch can be achieved on traditional instruments such as the violin and trombone and is often used in genres of music such as Indian classical music. On the other hand, western classical music is often produced on instruments such as the classical piano that use discrete pitches. While the extended form of this project caters for both types of music, i.e. music that comprises of discrete pitches such as western classical music as well as music that has a lot of pitch bends and microtones such as Indian classical music, the completed version evolves music from discrete pitches only.

5. GENETIC ALGORITHMS

Since we chose the evolutionary approach to music composition, it seems natural that we use genetic algorithms (The Genetic Algorithms Archive, 2004). The ideas are the same as those we find in the biological world. Species reproduce, taking some genes from each of the parents. They mutate at different rates. They compete as in the case of the sperms racing for the ovum. They also make choices and discard, abort or kill inefficient, weak or unsuitable offspring. In our project, we use all these techniques as well as additional techniques that mimic the behaviour of animals, particularly humans and monkeys when they ape each other, set some rules or norms on what may be considered acceptable or pleasant.

At various stages of this project, algorithms that mutate a piece of music are used. The piece thus mutated may be just a single pitch that may sometimes lead to an 'accidental' as in western music and Indian classical music, or a musical fragment consisting of several notes or even phrases. Both pitch and durations are mutated. The rate of mutation is usually set at around five percent. Using mutation, new musical ideas, fragments or phrases are generated. Mutation is particularly useful in composing in the genres of both western and Indian classical musics.

Crossover algorithms, which simulate the swapping of chromosomes in animals, are used to swap sections of two musical ideas, fragments or phrases, thus producing new offspring. These offspring, if they pass the fitness test, join the population and are ready to mutate and/or reproduce. Crossover is particularly useful in composing Indian classical music.

We introduce growth algorithms as a special kind of mutation algorithms that enable us to increase the size of each member of our population (i.e. Duration of the composition) at every pass. The ideas used here are based on both how humans evolved from earlier forms of life as well as how a tiny foetus grows into an adult. Growth algorithms are useful in composing in almost any genre of music.

5.1 STAGE ONE – MUSICAL IDEAS

In the first stage (Fig 1), a subset of the twelve musical notes are selected, either at random or based on a scale or key. The composing algorithm then combines these to form short musical fragments that consist of a few notes in length and are no longer than a brief musical idea at this stage.

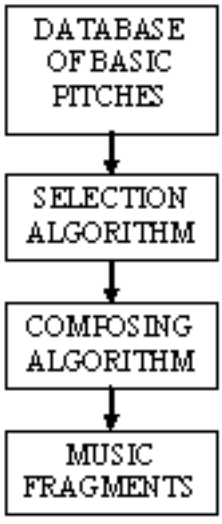

Figure 1 – Musical Ideas

Figure 2 – Selection Process

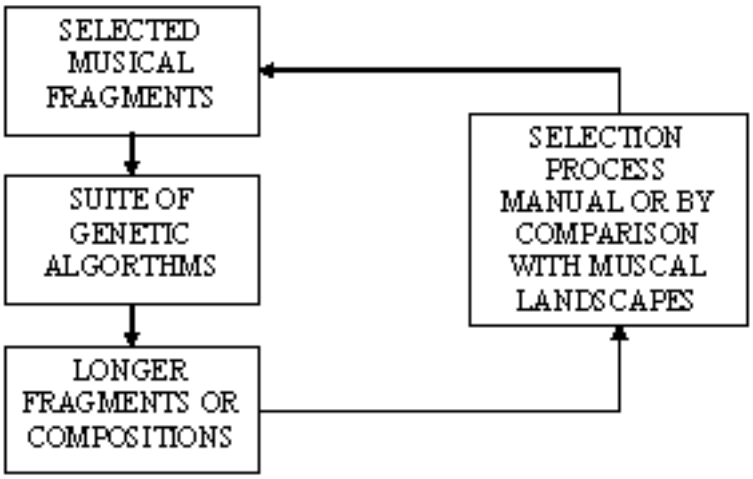

Figure 3 – Completing the composition

5.2 STAGE TWO - SELECTION

This is then played to a human listener who evaluates these fragments for fitness and either puts them in a basket or discards them with a mouse click. A selection algorithm called a fitness algorithm capable of making these decisions based on a database of musical landscapes (i.e. sets of pleasant and unpleasant melodic patterns in a given genre) is being developed. The fitness algorithm will also grade these fragments.

5.3 STAGE THREE – DEVELOPING THE COMPOSITION

Several genetic algorithms that mutate, combine and grow these musical ideas, both randomly and according to sets of various rules are then used to produce longer musical fragments. The rules here depend upon the genre of music being composed. The mutation applies not only to the notes but also to the other musical parameters.

5.4 COMPLETING THE COMPOSITION

A composition of any desired length is completed by repeating stages two and three as long as necessary. Each cycle results in a longer composition (Fig 3).

6. RESULTS AND FUTURE EVALUATIONS

The melodies generated by the software have been found to be pleasant to listen to by several people other than our friends. A group of people interested in music was invited for a presentation and we received some good comments. The results are so encouraging that this software will be further developed to be part of a larger project described below.

Future evaluations at various stages will be carried out by sending out recordings of the melodies generated by this software rendered by the rendering software, to a select group of musicians and musicologists. Depending on their feedback, selections will be made for public performances that will provide the ultimate feedback.

7. FURTHER WORK

This project is part of a larger project that will see the use of music not only for listening but also for therapeutic purposes in smart houses, especially for the elderly and others who may benefit from such therapy. Autistic children may stand to benefit. The smart buildings will eventually be able to sense the moods of people in various rooms and then either compose original music to suit and/or change the mood of the occupants. They might even compose and play music similar to the theme music from a cops and robbers programme when a burglar breaks into the building, to encourage a cop-like response

from the occupier, and/or a flee response from the burglar.

Another part of this large project is the expansion of multimedia entertainment to include real physical things moving in real 3-D. Music has gone from the days of the vinyl records, reel-to-reel and cassette tapes and CDs to music videos, i.e., sound and 2-D pictures. Walt Disney's 2-D cartoons and animated movies are losing ground to the new generation 3-D animated movies like Finding Nemo. Stationary action figures that perform, such as those in Tiki house in Disneyland, are limited in what they can do. These action figures are about to lose ground to robots with a lot more capabilities. Several kinds of robots are already in use in homes. The music composed by this programme will be rendered on standard MIDI synthesizers or on traditional and non-traditional instruments played by robots, i.e., including 3-D motion taking multimedia entertainment to the next level. Frank van der Hulst at UCOL, Wanganui is working on the implementation of a single robotic player for a Theremin. Based on this, Frank plans to build further players for different instruments.

An extension of this project may also see ideas used by Feldmeier *et al* (2004), utilised where dance movements by live human performers are picked up by wireless disposable sensors and music is composed in response to these dance movements, either leading or following the dancers.

Gerhard Widmer (2004) is studying how to add expressiveness to music performed by machines. When his findings become available, the human feel or expressiveness will also be implemented in our project.

8. CONCLUSION

The need to develop software capable of composing music-on-demand arose from the dream of a real 3-D multimedia entertainment system that can be used not only to entertain but also for education as well as well as for therapeutic purposes. The results so far are good and work is continuing towards the complete realisation of this dream.

REFERENCES

Bandai (2004), Bandai & Kenwood Team Up for Robotic Music Machine http://www.akibalive.com/archives/000522.html visited 27 May 2004.

Feldmeier, Mark et al, Large Group Musical Interaction Using Disposable Wireless Motion Sensors http://www.media.mit.edu/resenv/pubs/papers/2002-09-ICMC-ultralowcost.pdf visited 27 May 2004

Gaffurio, F (1492), Theorica Musica, Milan.

Lawler, Robert (1982), Sacred Geometry, Thames and Hudson, NY.

The Genetic Algorithms Archive (2005), http://www.aic.nrl.navy.mil/galist/ visited 27 May 2004.

Widmer, Gehrhard (2004), http://www.ai.univie.ac.at/oefai/ml/music/startproject.html visited 27 May 2004.

Woese, Carl (2002), http://unisci.com/stories/20022/0618021.htm visited 27 May 2004