When Darwin Meets Bossa: An Evolutionary Samba

Alan R. R. de Freitas
Departamento de Ciência da Computação
Universidade Federal de Ouro Preto (UFOP)
Ouro Preto, Minas Gerais, Brazil
alandefreitas@gmail.com

Frederico G. Guimarães
Departamento de Engenharia Elétrica
Universidade Federal de Minas Gerais (UFMG)
Belo Horizonte, Minas Gerais, Brazil
fredericoguimaraes@ufmg.br

ABSTRACT

This paper describes an approach used by the authors to create the computer music samba, *Darwin meets Bossa*, and a brief description and analysis of the evolutionary music algorithms devised by the authors for the composition process. Melodies were generated for flute and piano while harmonies were generated for acoustic and bass guitars. The percussion was generated by Markov chains. Three basic modules defined as melodic, harmonic and percussive generators were used by a higher level main algorithm to create the song. The result suggests how artificial life algorithms can help us create new original music.

Categories and Subject Descriptors

J.5 [**Arts and Humanities**]: Music; I.2 [**Computing Methodologies**]: Artificial Intelligence

General Terms

Algorithms, Design, Measurement

Keywords

Evolutionary Music, Algorithmic Composition, Computer Music, Genetic Algorithms

1. INTRODUCTION

Apart from the many challenges of the field [7], evolutionary computation still offers a very powerful structure for algorithmic composition and therefore many evolutionary and artificial life based applications have been developed for generating music [9, 8, 5, 1, 10, 6, 3, 4].

This paper describes the application of algorithms devised by the authors [3, 4] to create a Bossa Nova song, *Darwin meets Bossa*. Bossa Nova appeared in Brazil in the 1950s and originated from Samba with strong influence from American Jazz. It is nowadays an important style in Brazilian popular music. While discussing the song, we give a brief description and references for the algorithms employed. A main algorithm keeps a high-level structure of the song and coordinates three modules to generate melodies, harmonies and percussion for different parts of the song. The chief particularities of our algorithms are the following:

- A method for implicitly evaluating melodies is devised to deal with originality and diversity in the artificial evolution of melodies and an evolutionary multiobjective approach allows the compromise between different harmonic contexts.
- The melody generator can be influenced by the initial population as well as a compromise value in order to implicitly control the results, dealing with the fitness bottleneck [1] and leading to an appropriate result for the Bossa Nova context.
- Two different functions are defined for the harmonization problem in order to define musical contexts. A Pareto front is formed and the user can choose a convenient harmony. Thus, it is possible to find a compromise between different styles of harmony.
- The algorithms show (i) the possibility of dealing with different preferences of the user by generating a set of feasible solutions and (ii) an approach for the generation of new music without the necessity of very strict fitness functions that could overconstrain the creativity of the system.

2. TECHNICAL DETAILS

Three generators were developed to create different aspects of the song: melody, harmony and percussion. All those generators were used to form the song that has the following higher level structure: (i) intro, (ii) 1st verse, (iii) 1st chorus, (iv) 2nd verse, (v) 2nd chorus, (vi) solo, and (vii) final chorus.

2.1 The Melody Generator

A melody generator [4] was developed to generate melodies for piano (verse / chorus) and flute (intro / solo / chorus). This melody generator differs from other approaches in the following aspects:

- A population of musical measures and a fitness-free approach are used. Individuals from all generations are candidates to be in the final solution.
- Guided genetic operators respect the pulses when defining crossover or mutation points.

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- A *takeover matrix* is proposed to monitor the genetic loss of musical material. A *compromise value* is calculated according to this takeover matrix and used to decide which result shall be returned by the algorithm.
- The initial population and the trade-off between originality and diversity are used to control the algorithm and implicitly evaluate the solutions.

A different initial population was chosen for each part of the new song. The intro and the solo melodies were created from a simple chromatic scale with 8 notes per measure and a free-fitness selection. Yet the verses and choruses were respectively created with the verse and the chorus of *No More Blues*, by Tom Jobim and Vinícius de Moraes, as reference. *No More Blues* is a turning point in the creation of Bossa Nova.

2.2 The Harmony Generator

A harmony generator [3] was developed to create harmonies for acoustic and bass guitars having the previously generated melodies as reference. There are countless possible results for the harmonization process of a melody. In this harmony generator, a multiobjective approach is used to allow the evolutionary process to find sets of solutions which treat the conflicts between more than one set of harmonization rules, which can be used to define a musical context. Thus, a final harmony can be chosen from a Pareto front representing compromise solutions.

For the generation of the harmonies in *Darwin meets Bossa*, two fitness functions (dissonance and simplicity function [3]) were defined, and solutions with good values in the dissonance function were chosen to form the final harmony. That is intended to generate harmonies more suitable to the Bossa Nova context.

The problem is represented by a matrix in which musical measures and the melody notes performed during each measure are represented. Based on that matrix, a key for the song can be defined and the fitness functions can be calculated. Thus, any musical scale can be considered.

To rank the solutions in relation to all functions, a Non-dominated Sorting Genetic Algorithm-II (NSGA-II) [2] is used.

2.3 The Percussion Generator

A Markov chain was used to create the percussion of the song. A different Markov chain was defined for each of those drum pieces: (i) bass drum, (ii) snare drum, (iii) hi-hat, and (iv) crash cymbal.

Given several samba rhythms, the Markov chain considers the probability of the timing of the following note given the timing of the previous note. Following those probabilities, we have created different rhythms which are used in different parts of the song.

3. MULTIMEDIA FILES

Darwin meets Samba was made available online at http://www.purevolume.com/EvolutionaryMusic.

4. CONCLUSION

The results can give evidence of how genetic algorithms can be used for developing new ideas as well as extending previously created ideas. Also, multiobjective approaches can be used to deal with different preferences of users.

Darwin meets Bossa can give a taste of the effects of applying artificial evolution for the creation of music. We expect that the development of evolutionary approaches for algorithmic composition will continue to surprise us for years to come.

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5. REFERENCES

[1] J. A. Biles. Autonomous GenJam: eliminating the fitness bottleneck by eliminating fitness. In *GECCO-2001 Workshop on Non-routine Design with Evolutionary Systems*, 2001.

[2] K. Deb, S. Agrawal, A. Pratap, and T. Meyarivan. A fast elitist non-dominated sorting genetic algorithm for multi-objective optimization: NSGA-II. In *Parallel Problem Solving from Nature PPSN VI*, pages 849–858. Springer, 2000.

[3] A. R. R. Freitas and F. G. Guimarães. Melody harmonization in evolutionary music using multiobjective genetic algorithms. In *Proceedings of the 8th Sound and Music Computing Conference (SMC)*, Padova, Italy, 2011.

[4] A. R. R. Freitas and F. G. Guimarães. Originality and diversity in the artificial evolution of melodies. In *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO)*, Dublin, Ireland, 2011.

[5] A. Horner and L. Ayers. Harmonisation of musical progression with genetic algorithms. In *ICMC Proceedings 1995*, pages 483–484, 1995.

[6] B. Jacob. Composing with genetic algorithms. 1995.

[7] J. McCormack. Open problems in evolutionary music and art. In *Lecture Notes in Computer Science, Applications on Evolutionary Computing, EvoWorkshops 2005: EvoBIO, EvoCOMNET, EvoHOT, EvoIASP, EvoMUSART, and EvoSTOC*, volume 3449, pages 428–436. Springer, 2005.

[8] R. McIntyre. Bach in a box: The evolution of four part baroque harmony using the genetic algorithm. In *Evolutionary Computation, 1994. IEEE World Congress on Computational Intelligence., Proceedings of the First IEEE Conference on*, pages 852–857. IEEE, 1994.

[9] G. Papadopoulos and G. Wiggins. Ai methods for algorithmic composition: A survey, a critical view and future prospects. In *AISB Symposium on Musical Creativity*, pages 110–117. Citeseer, 1999.

[10] J. Polito, J. Daida, and T. Bersano-Begey. Musica ex machina: composing 16th-century counterpoint with genetic programming and symbiosis. In *Evolutionary Programming VI*, pages 113–123. Springer, 1997.