Expert systems and genetic algorithms applied to the twelve-tone musical composition

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Abstract. *We develop a prototype system in this work using an artificial intelligence technique through genetic algorithms, for musical composition within the twelve-tone serial system. The prototype was developed seeking to create compositions with melody and harmony within the atonal system, trying to keep the melodic coherence in the works. We create a set of rules inspired by expert systems techniques used in objective function, seeking the best intervals combinations to prevent sudden dissonance conflicts, maintaining the harmonic coherence and leaving only the atonal characteristic in evidence.*

1. Introduction

The creativity is one of the main requirements for an artistic work creation in general. Among many ways to express art, music stands out as one of the most widespread. Musicians and researchers of the artificial intelligence fields and computer music still have a big challenge to create new compositions of melodies through computers, because this involves emotion and creativity (Macdonald et al., 2006).

The relevance of the study was also observed in one of the objections provided by Turing, addressed in Russell and Norving (2004). This objection was quoted by Professor Geoffrey Jefferson, which states that only when a machine has the ability to write a musical composition, thinking and feeling emotions and not by the provision of the sounds at random, it would be possible to agree that the machine could equate to the brain (Russell and Norving, 2004).

In this work we propose a technique that born on the brain, not in the heart or ear. This approach can deal with an infinite number of compositions through a twelve-tone structure and create a twelve-tone composition taking care of some harmonic structures, leaving only the twelve-tone characteristic in evidence. The technique was implemented using Java, with jMusic library (Brown, 2005).

2. Methodology

We create a database with many rhythm structures to deal with the rhythmic values. The next step was coding the twelve-tone series using to perform the population for the genetic algorithms (Holland, 1992), that is developed looking for the best combination for all possible series.

The serial system was built based on the twelve-tone system. This series was constructed with the goal of establishing a structure for melodic ideas to form the basis for the creation of new compositions, in accordance with the serialism rules. From these series all the base of ideas for the compositions is done (Whittall, 2008).

We considered using genetic algorithms in order to select the best serie's combination from the twelve-tone system using this for melody and harmonization. The codification of the serial system considered each series of the twelve-tone system as an individual. We considered a binary codification, where each individual is encoded by its horizontal and vertical position on the system, as illustrated in Figure 1.

We created the complete serial system using the first two bits representing the reading position of individuals in the matrix and the others bits representing each individual position following the series. The individual's quantity on the population was considered constant throughout the evolutionary process. This means that for each new individual generated, another should be eliminated from the population.

	00 0000	00 0001	00 0010	00 0011	00 0100	00 0101	00 0110	00 0111	00 1000	00 1001	00 1010	00 1011	
11 0000	G4	C4	E4	D4	B4	A4	CS4	FS4	AF4	F4	EF4	BF4	10 0000
11 0001	D4	G4	B4	A4	FS4	E4	GS4	DF4	EF4	C4	BF4	F4	10 0001
11 0010	BF4	EF4	G4	F4	D4	C4	E4	A4	CF4	AF4	FS4	DF4	10 0010
11 0011	C4	F4	A4	G4	E4	D4	FS4	B4	CS4	BF4	GS4	EF4	10 0011
11 0100	EF4	AF4	C4	BF4	G4	F4	A4	D4	E4	DF4	B4	FS4	10 0100
11 0101	F4	BF4	D4	C4	A4	G4	B4	E4	FS4	EF4	CS4	GS4	10 0101
11 0110	DF4	FS4	BF4	GS4	F4	EF4	G4	C4	D4	B4	A4	E4	10 0110
11 0111	GS4	DF4	F4	EF4	C4	BF4	D4	G4	A4	FS4	E4	B4	10 0111
11 1000	FS4	B4	EF4	DF4	BF4	AF4	C4	F4	G4	E4	D4	A4	10 1000
11 1001	A4	D4	FS4	E4	CS4	B4	DS4	GS4	AS4	G4	F4	C4	10 1001
11 1010	B4	E4	GS4	FS4	DS4	CS4	ES4	AS4	C4	A4	G4	D4	10 1010
11 1011	E4	A4	CS4	B4	AF4	GF4	BF4	EF4	F4	D4	C4	G4	10 1011
	01 0000	01 0001	01 0010	01 0011	01 0100	01 0101	01 0110	01 0111	01 1000	01 1001	01 1010	01 1011	

Figure 1. Codification scheme for the individuals within the twelve-tone series.

The individual's performance was evaluated using an objective function inspired by the expert systems techniques. In this evaluation, the best combinations of intervals were selected to avoid sudden conflicts of dissonance, maintaining the melodic coherence and leaving only the atonal nature of the twelve-tone serialism in evidence. Thus, it was created a set of rules, responsible for assigning the fitness at every crossing-over operation between the individuals.

3. Results

We developed a web system prototype in order to generate the compositions. This platform works from basic input parameters that describe the basic information about the composition. These parameters are set from the composition name, amount of bars and style of the work. The developed system provides the option to write songs in jazz, sacrum, canon and minuets style. The amount of bars is variable according to the user's inspiration in each composition.

The first compositions were generated by a random selection of the series obtained by the twelve-tone system. Figure 2 shows a score fragment with the selected series and the indications of critical intervals in this work, where the red rectangles indicate a critical situation and the yellow ones should be avoided. After, we applied the genetic algorithm to deal with this scenario, as illustrated in Figure 3 and Figure 4.

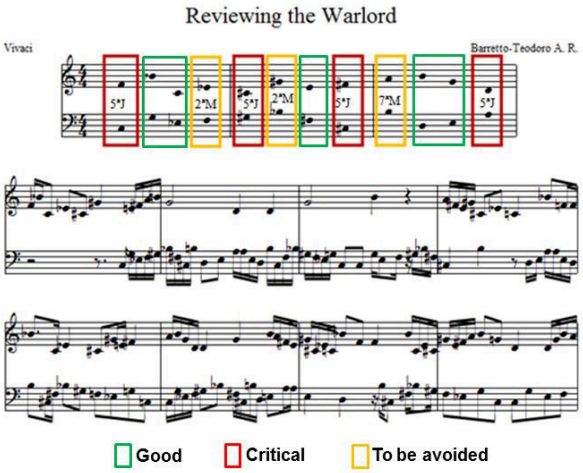

Figure 2. Composition fragment created from random series.

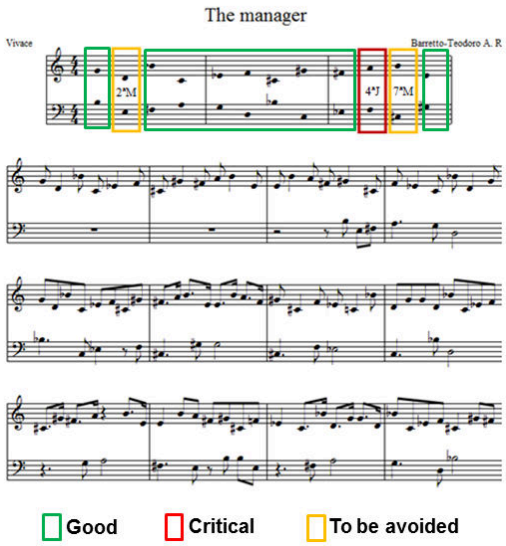

Figure 3. Composition fragment created by the genetic algorithm selection.

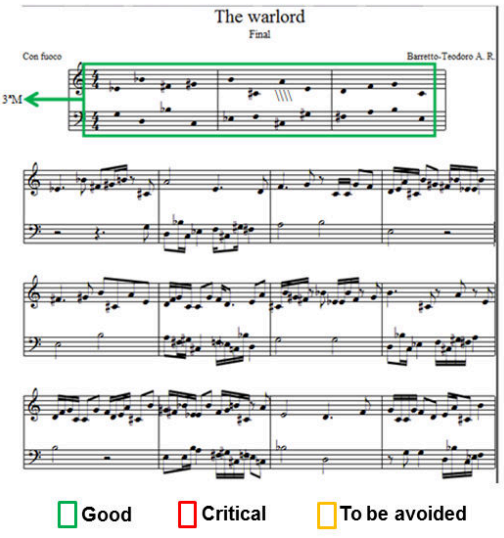

Figure 4. Best selection results obtained by the genetic algorithms.

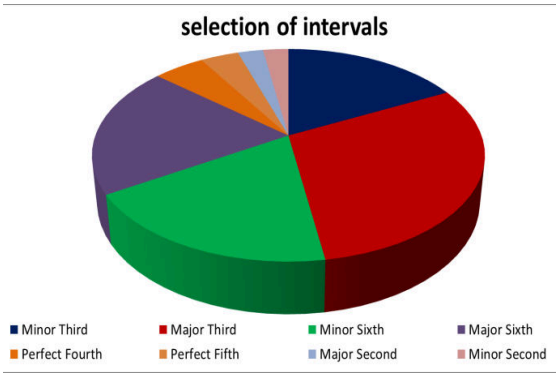

Figure 5. Number of occurrences for each interval.

The results confirm the good functioning of the genetic algorithms for the series' choice in the twelve-tone system and many of these results reached the good fitness desired as we illustrated in Figure 4. The total occurrences for each interval through the genetic algorithm selections are illustrated in Figure 5. We collected all the compositions generated using this algorithm and created the "Undergraduate Collection" album.

4. Conclusions

We presented in this paper a technique that is able to create musical compositions with melody and harmony from the serialism techniques using an artificial intelligence methodology, by genetic algorithms and expert systems. This work demonstrates that it is possible to create new compositions through computers and mix known elements, from a knowledge base. The application of artificial intelligence methods through genetic algorithms and expert systems at the atonal scenario were essential for best results.

The results obtained from the rigid rules of tonality can be more efficient in some harmonic situations. However, serialism has two major advantages: flexibility and creative freedom of creation. The proposal to work with the atonal system, through serialism, applying artificial intelligence techniques, expands the horizon of possibilities to create new compositions. This characteristic gets stronger by the fact that this new musical proposal born in the brain, not in the heart or ears.

We intend to extend this technique to others styles of compositions, like: waltzes, blues, tango and others. Another important task will be dealing with a bigger set of rhythms structure, working with compasses in quaternary, binary, ternary and both in simple, as in compounds.

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