Fusing Flamenco and Argentine Tango by Evolutionary Composition

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***Abstract*—Evolutionary composition has received considerable attention in these years. An automatic composition system based on evolutionary computation is attractive but very challenging because the evaluation function is difficult to design: First, human's evaluation on a composition is subject to personal feeling and preference. Second, different regions form their unique music genres from local customs, lifestyle, or ethnic history. These genres enrich music diversity and human sensation. This study presents an evolutionary composition system to address the above two issues. More specifically, the proposed system adopts general music theory rules as the fundamentals of fitness evaluation, thereby ensuring the basic harmony and consonance. In addition, we explore the specific musical expressions of Flamenco and Argentine Tango, and include their features in the evolutionary composition system to create a fusion. Experimental results show that the generated music is satisfactory and can express the emphases of both Flamenco and Argentine Tango.**

***Index Terms*—Evolutionary computation, music composition, Flamenco, Argentine Tango, genetic algorithm, music theory.**

I. Introduction

Composing music by using computational intelligence and artificial intelligence has emerged and been increasingly studied in recent years [1]. The automatic music composition is especially difficult because many musical elements need to be considered, such as musical form, rhythm, melody, and accompaniments. In addition, music genre is an important consideration in composing music, which usually consists of the features and styles related to specific regions. The musical genre poses a dilemma: if none of the features from any genre is considered, the music could be uncertain and ambiguous; on the other hand, overemphasis on a music genre may limit the creativity of composition since it uses some unique scales, chords, or rhythms. For example, in composing Chinese music, the pentatonic scale must be the majority of all the pitches, while the chromatic scale can only be used in special circumstances.

Evolutionary algorithms have shown their effectiveness in various optimization and search problems. Recently, evolutionary algorithms have been utilized to compose music and obtained some impressive accomplishments [2]. For instance, genetic algorithm (GA) has been widely used in the music composition systems. The musical notes are represented by a series of numbers in evolutionary composition. Nonetheless, the music genre is seldom considered in the phase of representation and thus need to be handled through the subsequent fitness evaluation. Several evolutionary composition systems adopt interactive genetic algorithm (IGA) to evaluate the compositions by interaction with humans. Although human feedback provides intuitive and useful evaluation, it is inevitably vulnerable to the fatigue and decreased sensitivity.

This study designs an evolutionary composition system to address the above issues. First, we adopt several rules from music theory to establish the fundamental fitness function for music evaluation, which considers the basic musical elements such as tune and harmony. Second, this study attempts to compose the fusion of two specific musical genres, i.e., Flamenco and Argentine Tango. These two genres derive from different regions and have their own unique styles; however, they also share some similarity and influence each other. In dancing, several Tango dancers are familiar with the Flamenco style and vice versa. These two styles have been combined as the FlamenTango and performed worldwide by two professional dancers Maria Serrano and Rimona Godoy [3]. To achieve the musical fusion of Flamenco and Argentine Tango, we adopt the scales, chords, and harmony from Flamenco due to the distinctive minor color, and the rhythms, musical forms, and melody progression from Argentine Tango owing to its characteristic musical structure.

The remainder of this paper is organized as follows. Section II reviews the related work. Section III describes the proposed GA for fusion of Flamenco and Argentine Tango. The experimental results are presented and discussed in Section IV. Finally, Section V gives the conclusions of this study.

II. Related Work

A. Evolutionary Composition

Evolutionary computation has been widely used in computational composition due to its recognized capability in global search and optimization. Laine and Kuuskankare [4] used GA to figure out the music functions and estimate the parameters for generating music. Pazos et al. [5] adopted GA and interacted with several musicians to build a model for creating rhythmic patterns. Furthermore, Marques et al. [6] generated and weighted the composition rules to distinguish good and bad music. Towsey et al. [7] analyzed some good

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music to find the features and divided the songs into five categories. They utilized these features with GA to evolve music. Khalifa et al. [8] adopted four motives for composing. These motives are evaluated according to the grammar rules. Liu and Ting [9] proposed using music theory to generate polyphonic accompaniments. The polyphonic accompaniments include main, chord, and bass accompaniments. These accompaniments are coordinated with the melody to achieve harmony. Wu et al. [10], [11] proposed a novel GA to imitate existing music by keeping the rhythm, chords and structure of phrases.

Some studies focus on a specific musical genre or the composition style of a specific musician. In light of a certain genre, the evolutionary composition system should consider its rhythms, scales, and structures. McIntyre [12] took the soprano, alto, tenor and bass part into account to generate four-part Baroque harmony. Dimitrios and Eleni [13] proposed the SENEgaL system, which creates the rhythmic music of Western Africa. The SENEgaL system contains different types of Western Africa rhythm: Gahu, Linjen, Nokobe, Kaki Lambe and Fanga, and each type has its unique rhythmic patterns. Wang et al. [14] analyzed the features of Chinese Jiangnan ditties. The features include the repeated rhythmic patterns and special intervallic motives. Liu and Ting [15] adopted music theory to define the fitness function and used the information from music charts of the rock band Guns N' Roses to determine the weights for the fitness rules. Furthermore, they [16] proposed using the sequential pattern mining technique to extract the music patterns from Jay Chou's compositions. These patterns are then used as genes for GA to generate new compositions. Papadopoulos and Wiggins [17] proposed a GA using jazz scales for chromosome representation. Biles [18], [19] developed the GenJam system, which generates jazz music and implements the trade four in impromptu. Tzimeas and Mangina [20] presented a GA-based system that can transform the Bach music into jazz music.

B. Flamenco

Flamenco is a special art form originating from Southern Spain. It contains three major parts: singing (cante), guitar play (toque), and dance (baile). Historically, Flamenco can be traced back to the 15th century in the Gypsy slums. It was merged with the Arab and Jewish music since the Arab, Jewish, and Gypsy pagans were all forced to escape into mountains due to religion issue. Hence, Flamenco music usually involves strong emotion of grief, protest, hope, and pride. The first record of Flamenco was written by Cadalso in 1793 [21]. Flamenco bloomed in the 19th century; at that time, many bistros and inns have Flamenco performance for entertainment. The amateur performers gradually grew to be professional and started to perform in formal occasions. The period 1869 to 1910 is the golden age of Flamenco. Since then, Flamenco becomes a formal performance in the opera.

C. Argentine Tango

Argentine Tango is one of the most popular forms of double dance. It was originally invented by Africa shepherds. Along with lots of European and African immigrants into Argentina, many of them loitered in Buenos Aires and exchanged their culture and art. Tango was later influenced by Flamenco and Italian dance and flourished in South America in the 19th century [22]. The common instruments of Argentine Tango music include guitar, piano, violin, and accordion. The music featured strong rhythmic feeling of staccato and emotions of loneliness, missing, love, and nostalgia. The accompaniment is usually filled with short notes to create rigorous pause points. Up to now, Argentine Tango has been developed into a world famous art and an important item of international dance competition.

III. Genetic Algorithm for Composition

Genetic algorithm (GA) has been extensively used in search and optimization problems. The concept of GA is to simulate natural evolution through the selection, crossover, and mutation operators [23], [24]. Based on the Darwinian theory "survival of the fittest," GA evolves the population toward the optimal solutions. The fitness function is used to evaluate the quality of individuals. The first step of GA is to represent the chromosome according to the problem to be solved. The evolution first initializes the population. In the reproduction procedure, two chromosomes are picked as parents by the selection operator. The two parents are then processed with crossover and mutation to produce their offspring. This procedure repeats until a predefined number of offspring are generated. The survivor operator draws the fittest chromosomes from the offspring population with (or without) the parent population. Those survival chromosomes will serve as the new population for the next generation.

The proposed evolutionary composition system consists of two stages: evolution and post-processing. The system first evolves compositions using GA. After 500 generations, the best resultant composition from GA is processed with musical form and accompaniment. In this study, we aim to create the fusion music of Flamenco and Argentine Tango. The elements of Flamenco are regulated in the fitness function at the first stage, whereas the elements of Tango are designed in the musical form and accompaniments at the second stage.

A. Representation

The musical notes are represented by a series of numbers according to the twelve-tone equal temperament. Each octave is divided into twelve notes to represent the musical pitches: C, #C, D, #D, E, F, #F, G, #G, A, #A, and B. Table I lists the notes and their corresponding numbers for the chromosome representation. Note C is encoded as number 0, #C as 1, D as 2, and so on. Specially, the rest and tenuto note are encoded as -1 and -2. The basic note length is set to a quarter of a beat and the variation can be achieved by using the tenuto note. Figure 1 gives an example chromosome, where bar 1 consists of four quarter notes, i.e., E, E, F, and G; the last bar

Table I
ENCODING OF NOTES

Note	Number	Note	Number
rest	-1	F	5
tenuto	-2	#F	6
		G	7
C	0	#G	8
#C	1	A	9
D	2	#A	10
#D	3	B	11
E	4	C (high)	12
		⋮	⋮

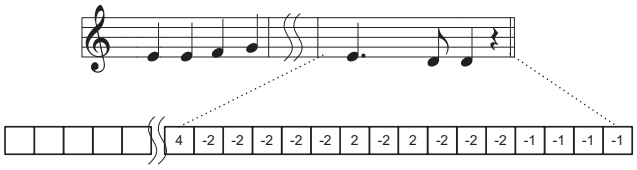
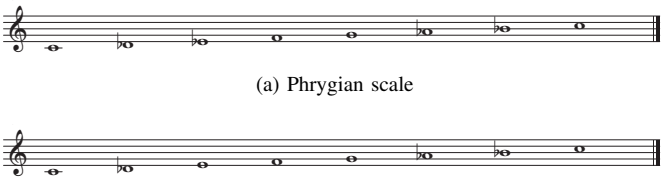


Figure 1. Chromosome representation



(a) Phrygian scale

(b) Phrygian Dominant scale

Figure 2. Common scales in Flamenco music

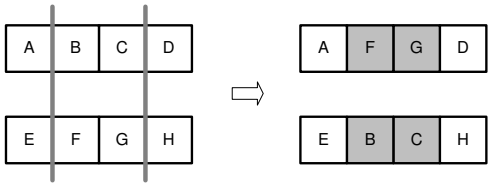


Figure 3. Crossover operation

contains dotted quarter note E, eighth note D, quarter note D, and quarter rest.

B. Fitness Function

Design of fitness function is a major issue that significantly affects the direction of composing music by GA. The proposed fitness function consists of two parts: general and specific. For the first part, we adopt 17 evaluation rules from music theory as the fundamentals of fitness function [25], [26]. These 17 rules focus on the basic consonance between connecting notes and the harmony with chord progression. Table II lists the general evaluation rules used in this study. The first rule gives a positive score for the length of chord notes to prevent the GA from generating many short notes. Rules 2–14 encourage using chord notes, especially for the beginning and last notes of phrases, because chord notes make the music section integrated. Rules 15 and 16 favor the chord notes on the stress beats in sections. The last rule promotes the resolution from active notes into inactive notes.

For the second part of fitness function, this study extracted 11 rules from Flamenco music theory [27]. Table III lists the adopted rules, which consider the melodic progression and notes. In Flamenco music, the most common scales are Phrygian and Phrygian dominant, as shown in Fig. 2. Rules 1–8 encourage the melodic progression on the scales in step or leap. Rule 9 provides an option for melodic progression in chromatic notes. The last two rules resolve the accidental notes, namely, the notes outside the scale.

The proposed fitness function renders three advantages: First, the evaluation criterion is consistent. The fitness function is generated by the general and Flamenco music theory rules, which provide an objective way to score the compositions, in contrast to the personal experience and preference used in the traditional interactive evolution. Second, the evaluation is stable. The fitness function based on music theory can effectively guide the GA to generate satisfactory compositions without suffering from human fatigue and the decrease of musical sensitivity after long-time listening. Third, the use of Flamenco scales and music rules effectively pours the flavor of Flamenco into the generated compositions. The compositions obtained from GA will be further processed with the Argentine Tango musical form and accompaniment to achieve the fusion.

C. Genetic Operators

The genetic operators of GA include parent selection, crossover, mutation, and survivor selection. This study uses the binary tournament for parent selection. The binary tournament selection chooses the better of two randomly picked chromosomes as a parent. Performing the selection twice gives a pair of parents for subsequent crossover and mutation operations.

The offspring are generated by the crossover and mutation operators. The crossover operator recombines the information of parents to produce offspring. In music composition, the crossover needs to be specially designed to prevent destroying the music structure. This study proposes the notion of crossover unit for the 2-point crossover to address this issue. In the modified 2-point crossover, the crossover points can only locate between sections (cf. Fig 3). The mutation operator is probabilistically carried out to slight change the offspring. This study adopts the random resetting mutation, which randomly picks a note (pitch, rest, or tenuto) and replaces it with a random value.

For the survivor selection, this study adopts the $(\mu + \lambda)$ strategy. This operator selects the better individuals from the union of parent and offspring populations for the next generation.

D. Post-processing

After the evolution stage, the post-processing is further performed to improve the composition generated by GA. This study utilizes the musical forms, bass and chord accompaniments, and rhythms extracted from Argentine Tango

Table II
GENERAL FITNESS EVALUATION RULES AND WEIGHTS

No.	General evaluation rules	Weight
1	The length of chord notes	+1
2	The note is a chord note (chord root note)	+5
3	The note is a chord note (chord 2nd note)	+3
4	The note is a chord note (chord 3rd note)	+3
5	The note of phrase cadence is the chord note	+1
6	The note of phrase cadence is not the chord note	+2
7	The note is the first note in a phrase and is a chord note (chord root note)	+5
8	The note is the first note in a phrase and is a chord note (chord 2nd note)	+3
9	The note is the first note in a phrase and is a chord note (chord 3rd note)	+4
10	The note is the first note in a phrase and is not a chord note	-8
11	The note is the last note in a phrase and is a chord note (chord root note)	+7
12	The note is the last note in a phrase and is a chord note (chord 2nd note)	+5
13	The note is the last note in a phrase and is a chord note (chord 3rd note)	+3
14	The note is the last note in a phrase and is not a chord note	-10
15	Chord note on stress	+1
16	Invalid note on stress	-3
17	Resolution from active note to inactive note	+3

Table III
FLAMENCO FITNESS EVALUATION RULES AND WEIGHTS

No.	Flamenco evaluation rules	Weight
1	Process of step on the scale (ascending)	+3
2	Process of step on the scale (descending)	+3
3	Process of step outside the scale (ascending)	-1
4	Process of step outside the scale (ascending)	-1
5	Process of leap on the scale (ascending)	+1
6	Process of leap on the scale (descending)	+1
7	Process of leap outside the scale (ascending)	-2
8	Process of leap outside the scale (descending)	-2
9	Process in chromatic notes	+1
10	Accidental notes	-2
11	Accidental notes between scale notes	+1

music theory [28]. The post-process consists of two steps, i.e., musical form and accompaniment, to fuse the Flamenco composition with Argentine Tango musical elements.

1) Musical Form: Musical form is considered in composition to generate the hook to the music. This study adopts the basic musical form of Argentine Tango, which has four paragraphs and the last paragraph is a repetition of the first paragraph, i.e., A–B–C–A. To accomplish the form, the first and last paragraphs of the compositions are compared to figure out which paragraph is better. The better paragraph will then overwrite the other to shape the form (see Fig. 4).

2) Accompaniment: The rhythm is an important element of Argentine Tango. To compose the Argentine Tango music, a key consideration is that the music is commonly used for dancing, instead of merely listening. Therefore, the rhythm should be clear and consistent. In this study, we adopt two rhythms for bass and chord accompaniments (see Fig. 5). Aside from rhythm, the Tango music regulates that the first note of every section in the bass part should be the chord root note and the rest notes can be any chord notes. This manner can ensure the harmony with the dominant melody and provide a stable progress of bass line. The chord accompaniment follows the rhythm of bass to accomplish harmony of the whole composition.

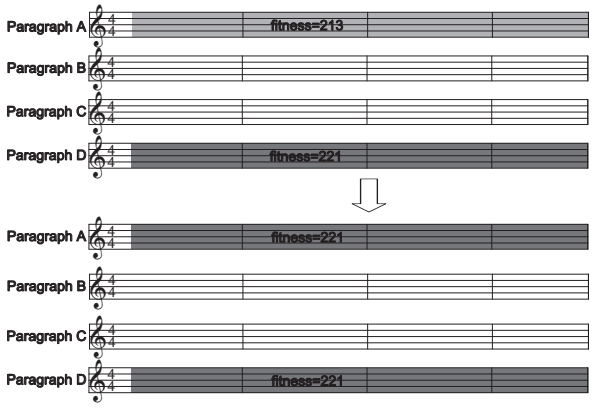


Figure 4. Example of musical form

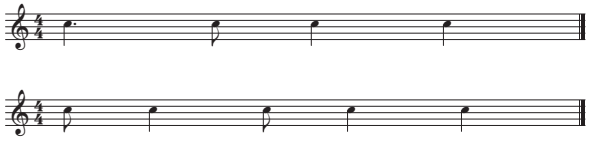


Figure 5. Common rhythm of Tango

Table IV
PARAMETER SETTING OF GA

Parameter	Value
GA type	Generational
Representation	Integer
Chromosome length	256 (16bars)
Population size	32
Selection	Binary tournament
Crossover	Modified 2-point
Crossover rate	0.9
Mutation	Random resetting
Mutation rate	1/256
Survivor	$\mu + \lambda$
Termination	500 generations

IV. EXPERIMENTAL RESULTS

This study carried out several experiments to evaluate the performance of the proposed evolutionary composition system. Table IV presents the parameter setting for the GA in the experiments. The length of compositions is set to be 16 bars, divided into four paragraphs. The obtained compositions are further processed with the virtual studio technology (VST). Some sample results (WAV files) can be downloaded via http://cilab.cs.ccu.edu.tw/CEC2017.zip.

Figure 6 plots the progress of mean best fitness over 30 runs of the proposed GA for generating the fusion of Flamenco and Argentine Tango. The figure shows that the GA can raise the fitness values of melody effectively. The results also demonstrate the improvement on initial random pieces. In addition, the compositions obtained from GA contain the flavor of Flamenco music.

Figures 7–9 compare the compositions obtained from different stages of the evolutionary composition system. The initial composition is generated randomly and thus has many discordant notes. It has a loose structure due to a large number of rest and tenuto notes. The connections between notes are disorganized and full of inconsonances. These defects are reflected on the low fitness values of the initial compositions. After 500 generations of evolution, the proposed GA improves the composition substantially. First, most of the inconsonances are resolved. This is achieved by the general music theory guiding the dominant melody into a consonance way through chord notes and emphasis on the stress points. Additionally, the notes in the beginning and end of phrases are well-regulated to maintain the cadence. Second, the rules of Flamenco music theory regulate the dominant melody to progress on the Flamenco scales by leaping or stepping. Even though the composition has some accidentals notes, they are resolved by the connection with scale notes. Finally, the post-process merges the composition generated by GA with the elements of Argentine Tango and enhances the structure and harmony.

The bass and chord parts adopt the common rhythmic patterns of Argentine Tango to emphasize the beats, providing a stable and harmonious accompaniment. Moreover, the musical form effectively completes the structure of compositions and generates the hook by repeating the first paragraph to make the music memorable. Figure 10 shows another composition obtained from GA and post-process. Compared to the composition in Fig. 9, the different chord progressions direct different ways of evolution and bring about two Flamenco melodies. Both compositions are generally consistent to Flamenco scales by leaping or stepping. The stress points are well emphasized. In addition, the different types of accompaniment give different rhythmic and dancing styles.

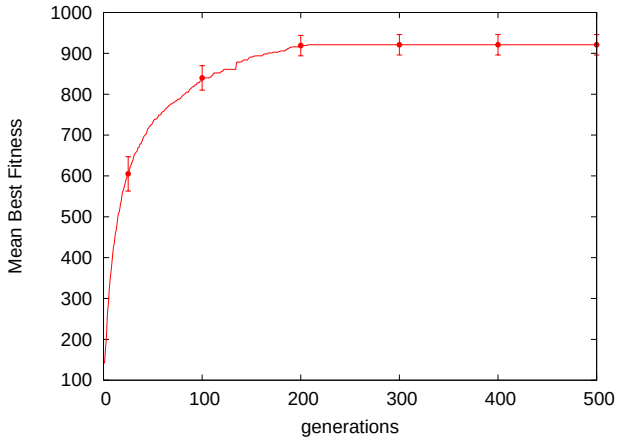


Figure 6. Progress of the mean best fitness against generations

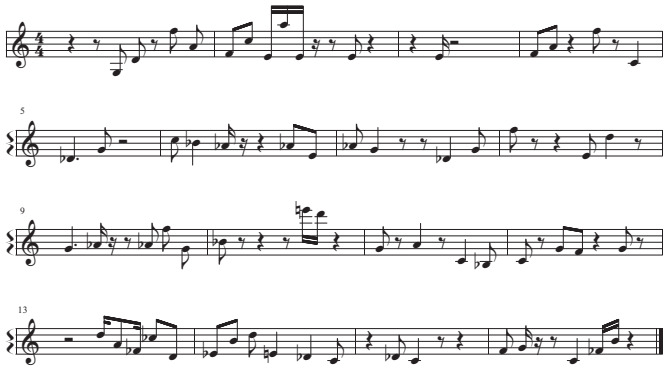


Figure 7. Resultant composition from initialization

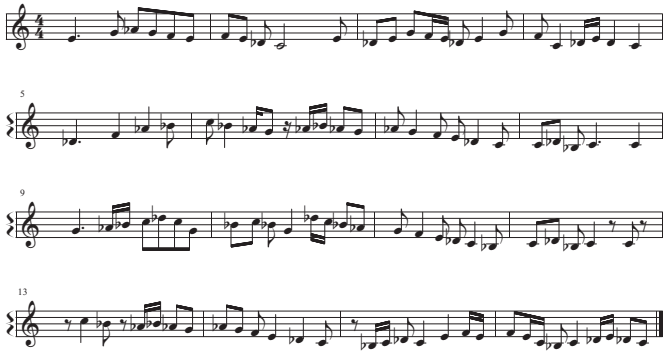


Figure 8. Resultant composition from GA

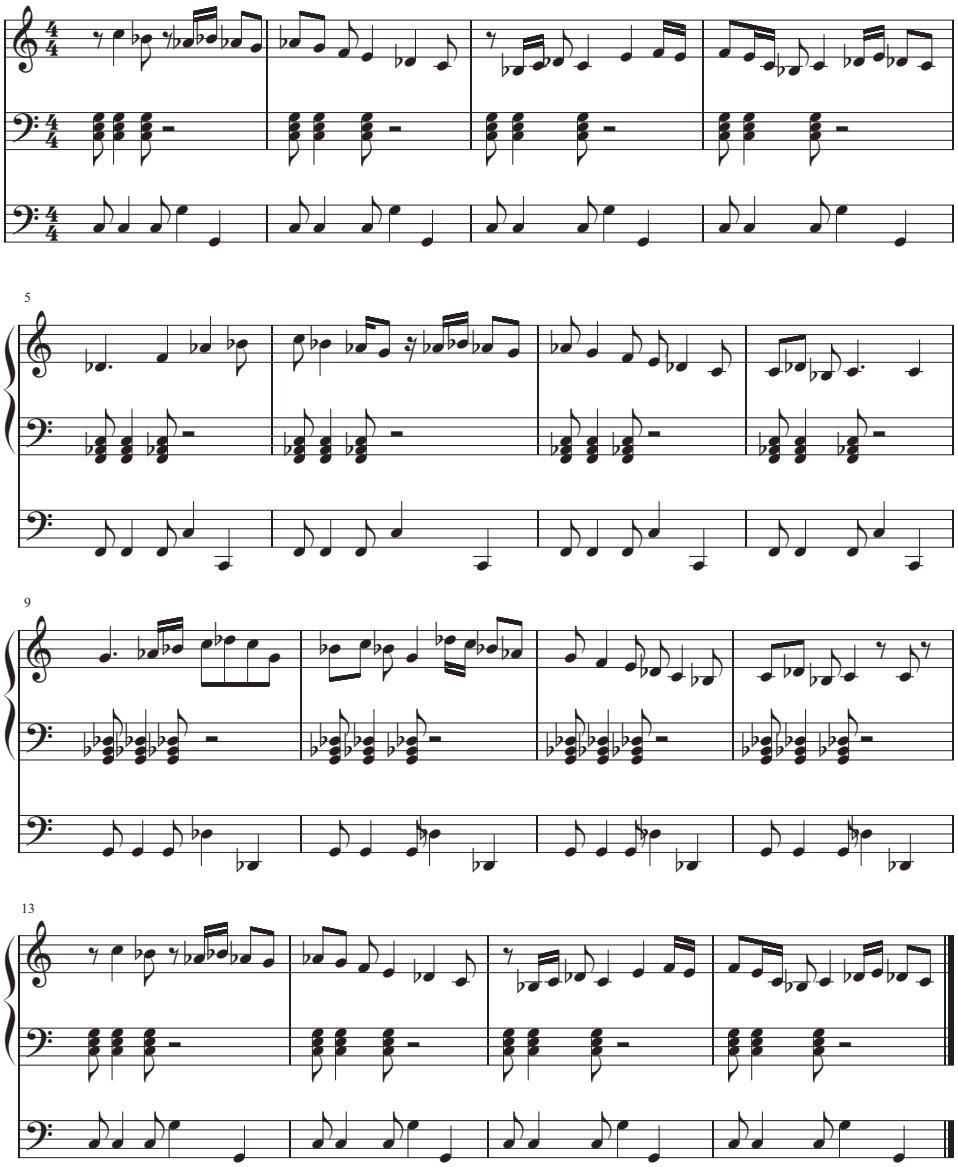


Figure 9. Resultant fusion composition from GA and post-process (I)

V. Conclusions

This study proposes an evolutionary system for composing the fusion of Flamenco and Argentine Tango. Specifically, we develop a GA for composition and design the fitness function based on general as well as Flamenco music theory. The resultant compositions are further modified according to the musical form of Argentine Tango and integrated with basic accompaniments.

The proposed evolutionary composition system has three major advantages. First, GA can produce diversity in the generated melodies owing to its stochastic property. Second, the proposed fitness function, which is based on the general and Flamenco music theory, provides an objective and consistent evaluation. The fitness function overcomes the fatigue and decreased music sensitivity in human-assisted evaluation. Using the rules based on Flamenco music theory, the fitness evaluation endows the features of Flamenco to the compositions. Third, beyond composition for a specific genre, the proposed composition system can even compose the fusion of two genres.

Experimental results show that the proposed method can effectively achieve satisfactory compositions. Based on general music theory, the evolutionary composition avoids generating disharmony and noisy melodies. The Flamenco scales and chords bring about the melody with Flamenco flavor. Furthermore, the post-process blends the elements of Argentine Tango to the resultant Flamenco-favored compositions to accomplish the fusion music. According to the audience with music background, the resultant compositions sound harmonious and

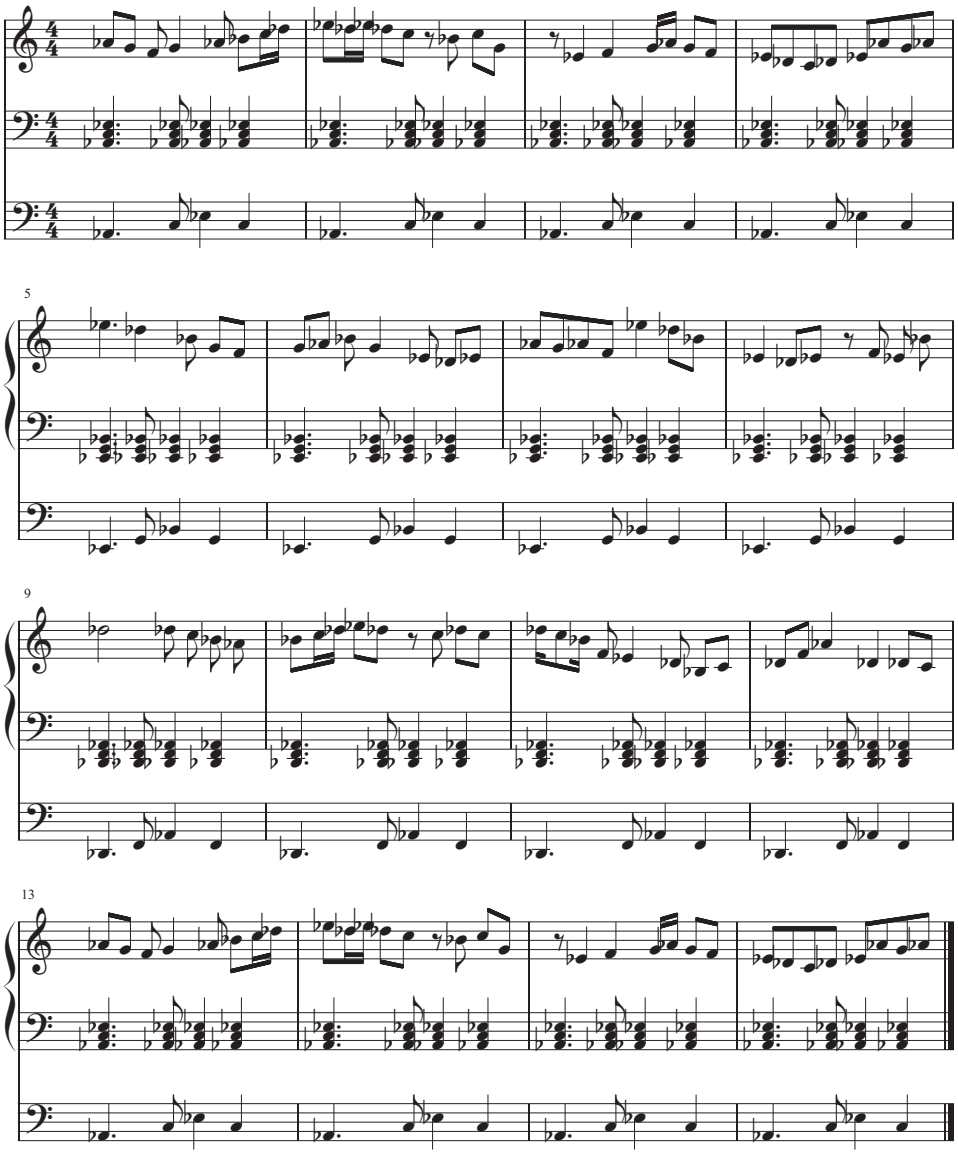


Figure 10. Resultant fusion composition from GA and post-process (II)

contain the features of Flamenco and Argentine Tango.

Some directions remain for future work. First, the fitness function can be improved by adopting more music theory rules to make it complete. Second, both the Flamenco and the Argentine Tango have several branches and styles. For example, the famous traditional forms of Flamenco music include Soleare, Siguiriyas, Tango and Fandango. Each of them presents special emotion and has its unique rhythmic patterns. These branches can be further considered in the composition system.

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