Construction of Music Composition System with Interactive Genetic Algorithm

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Abstract: This paper aims at the construction of the music composition system that has two important points. The one is that the system helps musically unskilled people to compose their own music. The other is that the system composes musical works reflecting users subjective evaluation of music. This paper uses the technique of Interactive Genetic Algorithm, since the interaction between users and the system is necessary to compose 16-bars music reflecting users feeling. The Interactive GA is a kind of an Interactive Evolutionary Computation as one of soft computing techniques. In the interactive GA, human evaluation is used instead of fitness functions. The subjects experiments are carried out in order to confirm the validity of the present system. From the results of the experiment, it is found that the subjects evaluation values become high with the progress of generations. That is, the system evolves and composes musical works reflecting user's feeling.

***Key words*:** *Music Composition, Interactive Genetic Algorithm, Human Interface, Human Evaluation, and Subjectivity*

1. Introduction

Music composition is usually a complex and difficult task for the people not having musical knowledge or skill, and composer's expertise plays an important role. Nevertheless, there have been many studies on automatic music composition using computer since the birth of the computer, and some automatic music composition systems have been proposed, for example, [1]. By the way, even if some persons listen to same music, impressions toward music are not necessarily the same [2, 3]. This characteristic is caused by the difference in the subjectivity toward music. Therefore, if a music composition system cannot reflect composers subjectivity toward music, it is difficult to compose music satisfying composers. Our research project aims at the design of the music composition system composing original musical works reflecting inexpert users subjectivity toward music. To this end it is necessary to consider the following two points. The one is that the composition system helps musically unskilled users compose their own music. The other is that the system reflects users subjectivity using their direct evaluation of musical works composed by the system.

In our project Interactive Genetic Algorithm (abbreviated as Interactive GA) is used for the design of a music composition system. GA is a global optimizing algorithm evolving candidates (chromosomes) using some fitness functions [4]. However, there are application fields in which fitness functions are difficult to be defined

objectively such as arts, industrial design. The Interactive GA using human direct evaluation instead of fitness functions is applied to such fields [5]. Many applications of GA and Interactive GA to the field of music composition are proposed [6]. Nelson tries to find and compose structured musical works using GA [7]. This study uses fitness functions to generate musical works, so it is different from our study which uses users direct evaluation instead of fitness functions. Biles constructs the interactive improvisation system named "GenJam", which is a composer agent playing jazz with human [8]. It aims at playing improvisation with human, so it is different from our study which aims at composing users own original musical works. Unemi constructs interactive music composition support system named "SBEAT" [9]. Unemi's system generates several kinds of 1-bar musical works and breeds them based on users evaluation. In his system if users want to compose musical works with more than 2-bars, users must connect some bars for themselves for the generation of long musical works. It is different from our study to design a system which helps musically unskilled users compose long musical works. Tokui constructs the system generating rhythm section (i.e. drum set) [10]. He uses the neural network approach to evaluate rhythm section. That is, the neural networks obtained by some learning method play the role of fitness functions. Johanson also tries to compose music automatically using GP (Genetic Programming) with fitness functions [11]. These studies are different from our method which evaluates composed musical works directly based on the users subjectivity toward music.

We have already proposed the music composition system which composes 4-bars music reflecting users feeling [12, 13]. This paper aims at constructing a system composing longer music, i.e., 16-bars music, whose length is moderately common, for example, among children's songs [14]. The procedure of music composition using the present system is as follows. Users, as composers of music, have feeling of musical work they want to compose. The system generates many chromosomes (candidates), where one chromosome corresponds to one 4-bars musical work. Then the system chooses several candidates which have musically better qualities among all chromosomes and presents them to users by the user interface. Next, users listen to them one by one, and evaluate them based on their subjectivity. And the system generates new chromosomes by GA operators based on users subjective evaluation. The system presents new musical works to users again. If users find a good musical work in presented ones, user can copy and keep it as a "Users Favorite" musical work. After repetition of these procedures and the interaction between users and the system, users get a favorite 16-bars musical work.

The overview of our interactive music composition system is mentioned in section 2. Subjects experiments are shown to confirm the validity of the system in section 3.

2. System Architecture

2.1 Overview

This paper describes the interactive music composition system composing 16-bars musical works whose length is common among children's songs. In composing music, musicians usually have the image of a melody line to compose in the first place, and then realize the image in the form of musical works by trial and error. In order to implement these procedures for the composition of musical works reflecting users subjectivity toward music, the interactive technique, i.e., the interactive GA approach, is used.

The interactive procedures between the system and users are shown in Figure 1. 1) Users have the image of music which they want to compose, for example "cheerful music." 2) The system generates 200 chromosomes automatically, where one chromosome corresponds to one 4-bars musical work. Twelve chosen chromosomes

(4-bars musical works) are presented to users through the user interface. 3) Users listen to them one by one and evaluate them based on their feeling. If users find a favorite 4-bars musical work among presented works, they select and keep it as "Users Favorite" musical works. 4) The system applies GA operators to the chromosomes based on the users subjective evaluations, and generates new generation chromosomes. Then 12 chosen chromosomes are newly presented to users again. These procedures are repeated until users compose satisfied 16-bars musical work.

Each procedure is explained below.

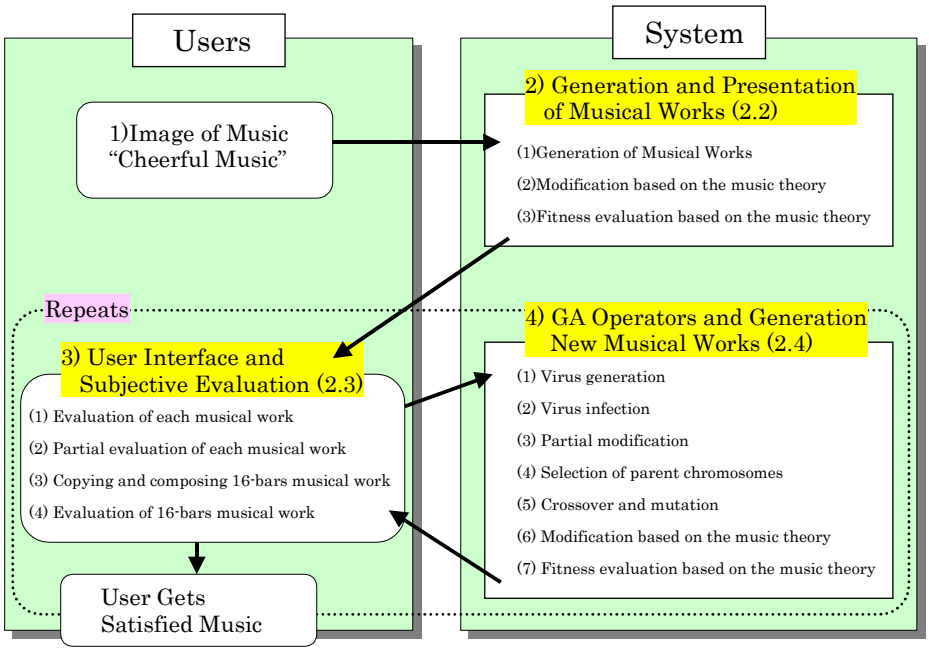

Fig. 1 Outline of Music Composition

2.2 Generation and Presentation of Musical Works

Music theory usually systematizes the music structure to give human better impression or feeling of music. In this paper the music theory is used so that composed musical works have rich expression and give listeners various kinds of impressions. The generation, the modification, and the evaluation of musical works at the first generation are done in the following way. (1) Two hundred musical works are generated based on the music theory. (2) Musical works are partially modified based on the music theory. (3) Musical works are evaluated by fitness functions defined by the music theory, and then twelve musical works are chosen from 200 musical works and presented to users. The systems design using the interactive GA has the problem that users have to repeat simple evaluation. The more users repeat evaluation of musical works, the more users feel fatigue. The above (2) and (3) aim at the efficient generation and the efficient presentation of musical works, respectively, in order to solve the problem.

(1) **Generation of musical works:** One chromosome corresponds to one musical work with four bars. The musical work is assumed to have five musical parts such as one main melody part and four backing parts (accompaniments). Pitches used in each part are chosen from notes in C-major scale. And musical works are fixed as 4/4 measures and 120 playing tempo. In this paper, a set of notes, called "block", is employed in order to generate a natural melody line. Three kinds of block types having 1 beat, 2 beats, or 5 beats are defined as shown in Table1, where 1, 2, or 4 block size is assumed to have 1, 2, or 4 beats, respectively. In

each block 4 kinds of note lengths are available. Therefore, the large size block is likely to have a set of long length notes, and the small size is likely to have a set of short length ones.

Table 1: Block Type and Note Length

Block		Note Lengths in a Block			
Type	Size				
A	4	4	3	2	1
B	2	2	1.5	1	0.5
C	1	1	0.75	0.5	0.25

4: whole note, 3: dot half note, 2: half note,
1.5: dot quarter note, 1: quarter note, 0.75: dot eighth note,
0.5: eighth note, 0.25: 16th note

Musical works are generated as follows. First of all, combination of 3 kinds of block types are chosen and arranged at random from the 1st bar through the 4th bar as shown in Figure 2. Therefore, four kinds of notes are chosen and arranged at random in each block. Variety of melody lines with comparatively the same length note combinations can be generated, which are easy to listen [14]. Next, the chord is assigned to each bar based on the theory of chord progression, and the pitch of each note is determined according to the dynamical level of the beat position and the chord. It is known that there are beat positions which are felt strong or weak in a melody line, and that a melody line becomes better if pitches with the fundamental note of a chord (called "Consonance") are assigned to the strong beat position, or if pitches without the fundamental note of a chord (called "Dissonance") are assigned to the weak beat position [15, 16]. Finally, scores of four backing parts (Guitar, Piano, Bass, and Drums) are generated according to chord progression. The pattern of "Rock and Roll #1" [17] is fixed as those backing parts patterns (length and note pitch transition), and scores (actual each notes pitches) are changed according to the chord name [15].

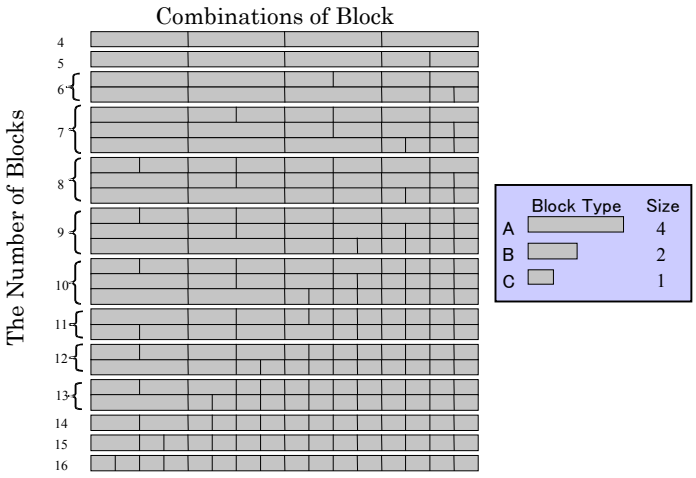

Fig. 2 Block Type and Combination Through 4-Bars Musical Work

(2) **Modification based on the music theory:** Some parts of melody lines are modified based on the music theory in order to generate better musical works. 1) If the last note pitch of the melody line is outside the chord, then it is changed to the note pitch within the chord. 2) If the interval between the present note pitch and the next note pitch is irregular (i.e., the interval between two notes is 6 or 8), then the note pitch is changed to the note pitch with the regular interval.

(3) **Fitness evaluation based on the music theory:** In order to choose some better musical works out of many works and present them to users, four kinds of fitness evaluations are prepared based on the music theory.
A) If there are many notes whose pitch is within a chord in the musical work, the fitness value becomes high.
B) If there are many notes whose pitch is outside a chord in the musical work, fitness value becomes low.
C) If a certain note beat position is strong and its pitch is within a chord, the fitness value becomes high.
D) If a certain notes progression in the melody line is natural or has rich expression, the fitness value

becomes high.

After the generation of chromosomes, the modification and the evaluation based on the music theory, twelve chromosomes with high fitness values are chosen and presented to users through the user interface.

2.3 User Interface and Subjective Evaluation

Twelve musical works are presented to users through the user interface as shown in Figure 3. The user interface is designed in order to lighten the users fatigue in the evaluation of presented musical works. In the top of the interface, four tab window pages are displayed, and three musical works are presented in each tab window. These tab windows are called sections 1, 2, 3 and 4, respectively, where 1st~4th bars, 5th~8th bars, 9th~12th bars and 13th~16th bars in 16-bars musical works are presented in sections 1, 2, 3 and 4, respectively. Each note in the melody line is shown by the rectangle, whose vertical position represents the pitch and horizontal length represents the length. Seeing these rectangles, users can get information on a melody line without listening to it. For example, "this work has many long length notes", or "this is similar to the work listening before," and so on. After the second generation, GA operated notes of a melody line are colored (green, blue, or yellow) so that users can visually understand which sections in a melody line are changed.

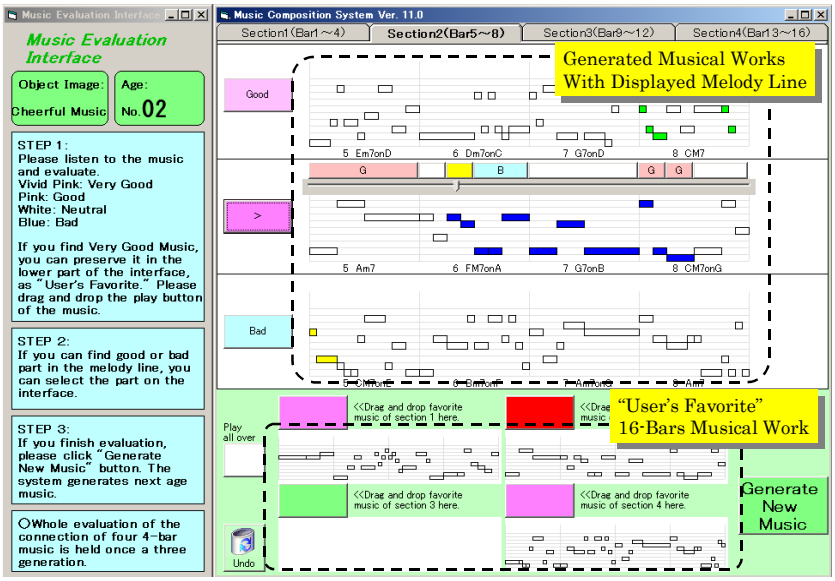

Fig. 3 User Interface

Users listen to musical works one by one, give an evaluation point to each work, and choose a favorite musical work at the procedure of subjective evaluation. The following evaluations are considered and evaluation results are reflected in the generation of next chromosomes.

(1) **Evaluation of each musical work:** Users listen to presented 4-bars musical works and evaluate the whole impression based on their subjectivity toward music. Users click the play button with the left mouse button in order to listen to the 4-bars musical work. After listening to it, users click the play button with the right mouse button in order to evaluate it with a 4-point scale. The button's color turns into pink, red, white or blue according to users evaluation "Good", "Very Good", "Neutral" or "Bad", respectively.

(2) **Partial evaluation of each musical work:** If users find good or bad part(s) in a melody line, users point out the parts of the melody line pressing the "Good Part" button or the "Bad Part" button. When users click the play button of each musical work, the *partial evaluation buttons* and the progress bar appear at the top of

playing musical work's melody line. The pointer in the progress bar moves and shows the playing position of the melody line, and the pointed partial evaluation button color turns into yellow. If users feel good in the part of the melody line, they evaluate the part by clicking the left mouse button, and then the button color turns into pink. If users find the bad part, users click the right mouse button, and then the button color turns into blue.

(3) **Copying and composing 16-bars musical work:** If users find a favorite musical work, users can copy it into the "User's Favorite" area at the lower part of the interface. In this area four spaces are prepared and users drag and drop favorite works to these spaces. Four 4-bars musical works are preserved in this area, and if users find more satisfying musical works, these are preserved again. Users compose a favorite 16-bars musical work reflecting user's feeling of music in this area.

(4) **Evaluation of 16-bars musical work:** The favorite 16-bars musical work is evaluated whether the work is good or not as a whole. This kind of evaluation is done once a three generations with a 5-point scale (+2, +1, 0, -1, or -2).

2.4 GA Operators and Generation New Musical Works

The system gives GA operators to chromosomes according to the users evaluations, and composes next generation chromosomes (musical works) at the procedure of generation of new musical works. The following GA operators are considered here.

(1) **Virus generation:** Part of a melody line evaluated "Good Part" by users is kept as "Virus." Each virus has information on the set of notes of the melody part.

(2) **Virus infection:** The system copies viruses to the part of a chromosome in order to reflect user's favorite melody line directly as shown in Figure 4. The maximum number of newly generated viruses is four, and the number is decreased one by one every generation. The overview of virus generation and infection is shown in Figure 4. Virus generation is carried out after the crossover and mutation operator.

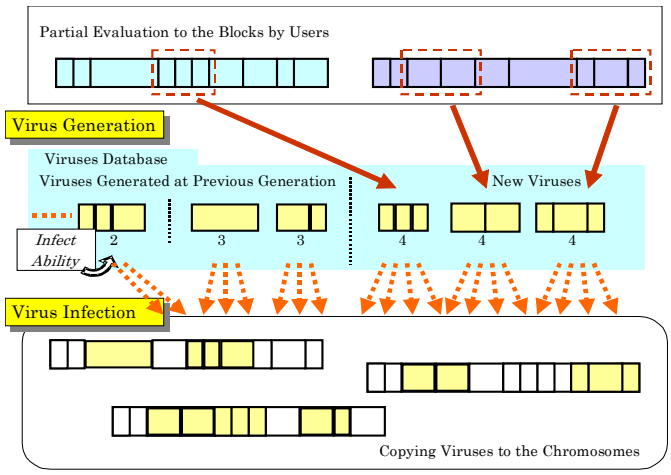

Fig. 4 Virus Generation and Infection

(3) **Partial modification:** Part of a melody line with "Bad Part" evaluation is modified 1) by replacing the part with the Virus generated in (1), 2) by replacing the part with the part of 4-bars music with "Good Part" evaluation, 3) by replacing the part with the part of randomly chosen 4-bars music, or 4) by regenerating the part newly. Operations 1), 2), 3) and 4) are operated in the numeric order, for example, if there are no viruses which are able to be replaced at operation 1), then system operates operation 2).

(4) **Selection of parent chromosomes:** Fifty parent chromosomes are selected in each section as shown in Figure 5. 1) A chromosome with "very good" or "good" evaluation is copied fivefold. A chromosome with neutral is copied one. 2) A chromosome in the user favorite area is copied $(5+\alpha)$-fold, where α is defined according to the whole evaluation of 16-bars musical work; "very good", "good", "neutral", "bad" or "very

bad" corresponds to +4, +2, 0, -2, or -4 respectively. 3) A chromosome with "very good" or "good" evaluation in other sections is copied twofold or one, respectively. 4) Ten chromosomes are newly generated. 5) Deficiencies of 50 chromosomes are randomly chosen from the original pool, in which 200 chromosomes at the present generation are preserved. These selection procedures are repeated 1 through 4 sections.

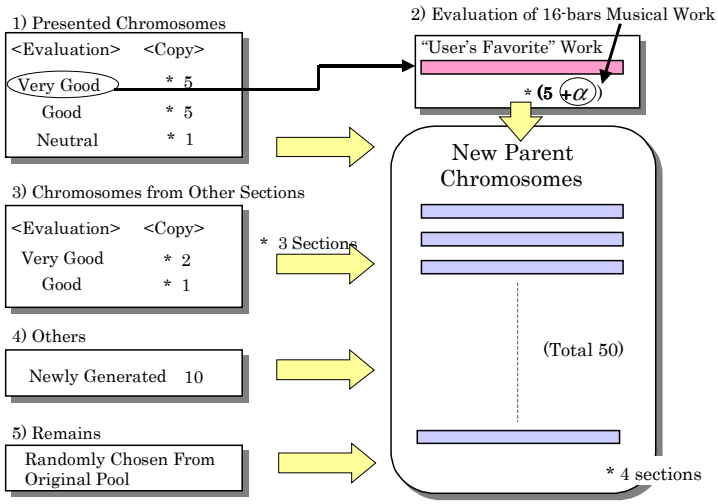

Fig. 5 Selection of Parent Chromosomes

(5) **Crossover and mutation:** The crossover operation is defined as the copy operation from the part of a chromosome to another one in this system. Crossover is given to 1, 2, 3, or 4 blocks of the same size and the same chord name. If both of the block information in chromosomes A and B are the same, then the system copies the block in chromosome B from the one in A. The probability of the crossover is defined as 70 percent. After the crossover, the mutation occurs to 30 percent of chromosomes. Mutation is defined as the re-construction of some blocks of the melody part in this system. The example of crossover and mutation operation is shown in figure 6.

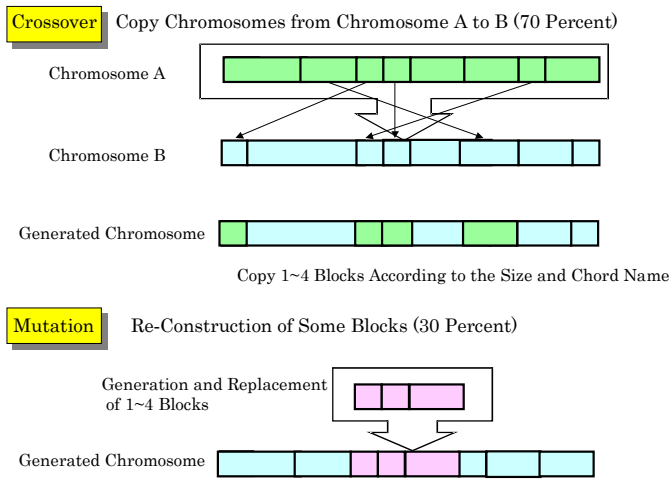

Fig. 6 Crossover and Mutation

(6) **Modification based on the music theory:** Some parts of melody lines are modified based on the music theory in order to generate better musical works. This operator is mentioned in (2) at 2.2.

(7) **Fitness evaluation based on the music theory:** Fitness evaluation based on music theory is given to the chromosomes. This operator is mentioned in (3) at 2.2.

After these operators, the newly generated musical works with good fitness values are presented to users again through the user interface. The user listens to them and evaluates again.

2.5 Features of Present System

The partial evaluation is one of features of the present system. There are many studies using the evaluation of whole impressions of musical works, e.g., [8] and [9]. The present system, however, uses not only the whole evaluation but also the partial evaluation as mentioned in 2.3. The users' favorite of a melody line in the partial evaluation is reflected in the music composition by the GA operations such as the virus generation and the virus infection. On the other hand the bad partial evaluation is reflected in the music composition through the partial modification.

The system structure aiming at the composition of 16-bars musical works, which has four sections

composing 4-bars musical works such as 1st-4th bars, 5th-8th bars, 9th-12th bars, and 13th-16th bars, is another feature of the present system. Owing to this system structure similar melody lines are not always composed by the copying operation of users' favorite part of melody lines but independent melody lines can be often composed in each section. Furthermore, the composed melody line is heard as not a non-connected melody line but a connected one since 16-bars musical works are evaluated whether they are good or not as a whole.

3. Evaluation Experiments

3.1 Procedure

To confirm the validity of the present system, 6 subjects from 20 years old to 30 carry out the evaluation experiments. They try to compose favorite "cheerful musical work (with 16-bars)" using the present system. It is assumed that the first generation chromosomes have the same data among all subjects. The subjects repeat listening to and evaluating presented musical works until 15th generation presentation phase. After the experiments, favorite 16-bars musical works composed by the subjects at the 3rd, 6th, 9th, 12th and 15th generation, are presented to the subjects at random. And the subjects listen to and evaluate five musical works with a 5-point scale based on his/her own feeling of "cheerful music".

3.2 Results and Remarks

Figure 7 shows the average of subjects evaluations of their favorite musical works at every three generations, where the horizontal axis expresses the generation and the vertical axis expresses the average evaluation value among 6 subjects. It is found that the value becomes high with the progress of generations. Figure 8 and Figure 9 shows the melody part scores composed by two subjects. Although the subjects try to compose "cheerful musical work" in the experiments, it is found that various musical works with different melody line are composed reflecting their subjectivity toward music. These results show that the present system can compose musical works reflecting each user's subjective evaluation of musical works.

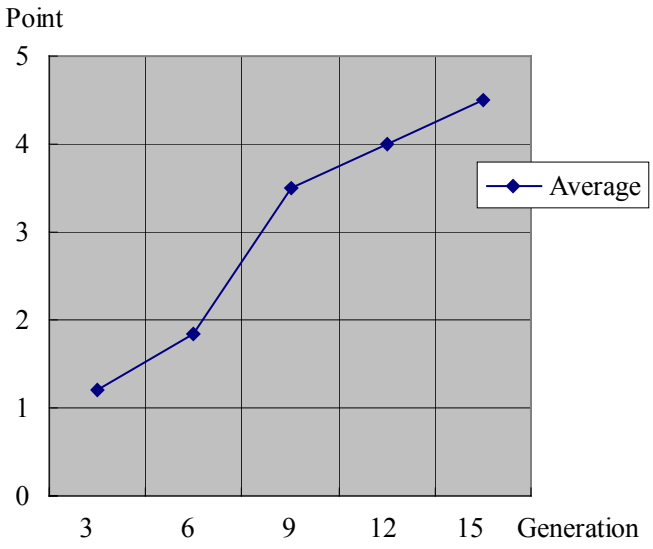

Fig. 7 Average Point of Subjects Evaluation

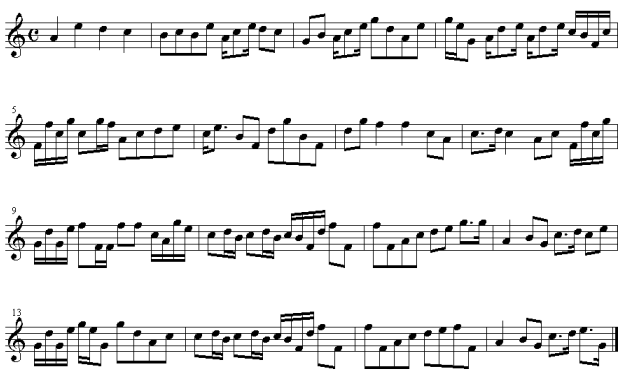

Fig. 8 Example of Generated Melody Lines (1)

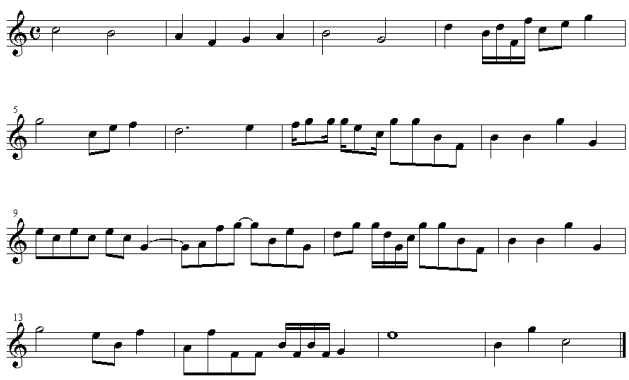

Fig. 9 Example of Generated Melody Lines (2)

The repetition of some part, which has high partial evaluation by some subject, is observed in the musical score shown in Figure 8. This is the typical example of the partial evaluation effect mentioned in 2.5. The musical score shown in Figure 9 is the typical example of the musical work reflecting the feature of the system structure mentioned in 2.5. That is, although four 4-bars musical works are independent of each other, they are heard as a connected melody line.

4. Conclusions

This paper describes an interactive music composition system based on users subjective evaluations, by which 16-bars musical work reflecting users image (feeling) of music is composed. One chromosome corresponds to 4-bars musical work information and the GA operators are given to chromosomes according to three kinds of users subjective evaluations. In order to lighten users load, the user interface for the presentation and the evaluation of generated musical works is designed. Users can get information on each musical work melody line visually. From the results of the experiments, it is found that the average point of subjects evaluation values of composed musical works become high with the progress of generations. That is, the system evolves and composes musical works reflecting users evaluation.

Future research tries to construct the generating longer music with various types of backing parts. For solving the problem, the construction of the users personal database of evaluation record and users favorite backing part pattern is considered.

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