A Chord Progression Creating System Reflecting User's Kansei

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***Abstract*— In this paper, we propose a chord progression creating system reflecting user's Kansei. Chord progression is an important element in music. However, conventional automatic music composition methods have undervalued chord progression and it is one of the biggest problems of them. We focus on creating chord progression to improve automatic music composition. The proposed system operates with interactive genetic algorithm to create chord progressions that reflect individual Kansei. The input to the system is an impression of a chord progression that the user wants to create. The system creates the first generation based on the user's input. The user listens to created chord progressions and evaluates each one subjectively. The system creates the next generation by genetic algorithm based on the feedback from the user. By repeating this process, output will get close to the user's demand gradually. Through experiments, the effectiveness of the system was confirmed.**

I. Introduction

Computers have enabled us to perform enormous calculation and various data processing. They have made our life convenient and affluent. However, it is difficult for computers to do what we can do easily. Now computers are required to perform intelligent information processing like human beings. Music composition is one of the most intelligent activities of human beings. It is very difficult because music composition needs considering many elements. Therefore, the trial of composing music using the computer automatically (automatic music composition) has been studied for many years [1]. Music is divided broadly into three elements: melody, rhythm and harmony. Conventional automatic music composition methods have focused on creating melody mainly among them. The other elements should be prepared in many cases. However, the impression of melody is strong indeed, they are also important because every element influences each other. Chord is a combination of two or more notes played at the same time. Chord progression is a series of chords played in an order. It is the foundation of a melody and determines the atmosphere of music. Good music has impressive chord progressions. In other words, it is necessary to consider chord progression in order to create good music. It can be said that chord progression has been undervalued in automatic music composition, however. It is one of the biggest problems of the conventional automatic music composition. It is essential to create various and good chord progressions in order to improve automatic music composition.

We will have different impressions even if we listen to the same music. This is because each of us has different Kansei (sensitivity). Therefore, it is necessary to create chord progressions reflecting individual Kansei. To reflect individual Kansei, interactive genetic algorithm is employed in the proposed system. Interactive genetic algorithm is classified as evolutionary algorithms which uses human evaluation instead of a fitness function. It is effective to a problem in which a fitness function is difficult to design [2]. Some applications using interactive genetic algorithm to the field of music have been proposed [3]-[5].

In this paper, chapter II explains the proposed system in detail, chapter III shows the effectiveness of the system by experiments, and chapter IV concludes the paper.

II. Chord Progression Creating System

A. Overview of the System

Fig.1 shows the overview of the proposed system. The purpose of the system is to create chord progressions which reflect user's Kansei. The system operates with interactive genetic algorithm. Chord progressions created by the system have following characteristics.

- The key is C major or A minor.
- The key doesn't change halfway.
- Diatonic chords are used mainly.
- The length is 4 bars.
- 8 rhythm patterns are prepared.

The initial input to the system is an impression of a chord progression that the user wants to create. Table I shows the

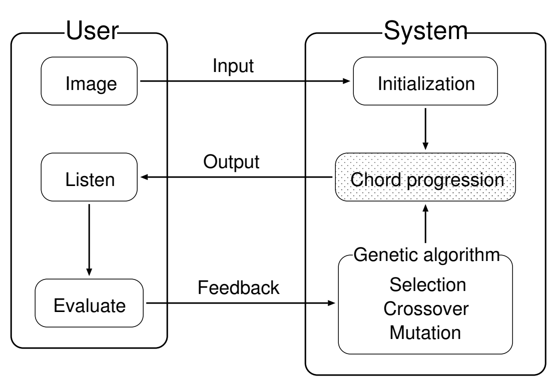

Fig. 1. Overview of the system

TABLE I

Impression words used for input

Gloomy	–	Bright
Simple	–	Complex
Mild	–	Intense

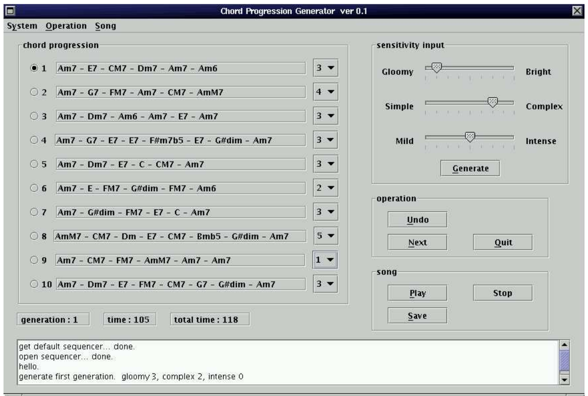

Fig. 2. User interface of the system

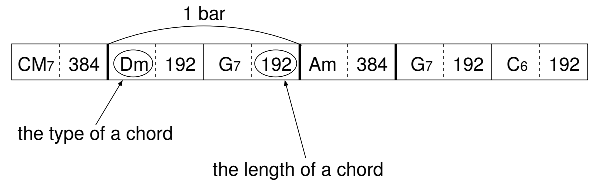

Fig. 3. Representation of a gene

impression words used for the input. As shown in Table I, the system uses three pairs of adjective. "Gloomy – Bright" corresponds to brightness B. "Simple – Complex" corresponds to complexity C and "Mild – Intense" corresponds to intensity I likewise. These three variables are used for initialization and determine the sound of created chord progressions. These words were selected based on the concern with chord progression. By using such words for the input, the user can create chord progressions even though he/she doesn't have the knowledge of music.

After the user inputted, the system initializes some parameters based on the user's input. Then, the first generation is created by these parameters. The genotype of an individual is a series of chords played in an order. The output of the system is 10 chord progressions of 4 bars. The length of 4 bars is suitable for listening and evaluating. Chords are inverted appropriately. Chord progressions are played with MIDI. MIDI is the standard for treating musical data among computers and electronic instruments. The user listens to each chord progression and evaluates each one subjectively. These scores are used for fitness of individuals and the next generation is created by genetic operations. By repeating this process, output will match the user's demand gradually. This process is repeated until a chord progression that satisfies the user is obtained.

Fig.2 shows the user interface of the system. As shown in Fig.2, the user operates three sliders to input the degree of each impression.

B. Initialization

This section elaborates on the initialization of genes. The tempo, the key and the rhythm of each individual and three sets of probabilities are determined based on the user's input. Then, individuals of the first generation are created by using these probabilities. The following is the explanation of each factor.

Key: Key is a set of notes in terms of pitch and it is the basis of melody and harmony [6]. Two kinds of keys are used mainly in popular music: major keys and minor keys. Generally, the atmosphere of a song is bright if the key of the song is major and gloomy if it is minor. The key is determined by B. The key of individuals is C major if $B = 1$, whereas it is A minor if $B = -1$. In this system, the key of a chord progression does not change halfway.

Tempo: Tempo is the speed at which music is played and it is usually given as the number of quarter notes per minute. Tempo influences the atmosphere of a song in terms of intensity. First, the base tempo is determined and then the tempo of each individual is determined. By this method, tempos of individuals vary on the basis of the base tempo. The base tempo t_b is defined as

$$t_b = 100 + 10 \cdot I \quad (-4 \leq I \leq 4). \tag{1}$$

Therefore, t_b is from 60 to 140. The tempo of each individual t_i is given as

$$t_i = \begin{cases} t_b - 10 & (r_g < -1) \\ t_b & (-1 \leq r_g \leq 1) \\ t_b + 10 & (1 < r_g) \end{cases} \tag{2}$$

where i is an individual number and r_g is a random number of normal distribution.

Rhythm: There are three basic rhythms in the system. Basic rhythm is a pattern of the length of chords in a bar. Eight rhythm patterns which are composed of these three basic rhythms are prepared and used for the rhythm of an individual. The rhythm of each individual is selected from these eight rhythm patterns based on the value of I. If I is small, mild rhythm patterns will be selected. The bigger I is, the more intense rhythm patterns will be selected.

Fig.3 shows the representation of a gene. The genotype is an array of chords played in an order. Each gene locus has the type and the length of a chord. MIDI tick is used for the length of a chord. The value of the length of a quarter note is 96 in the system.

Fig.4 shows the initialization of a gene. In the system, three sets of probabilities are used to create chord progressions of the initial generation. These probabilities are models of popular music theory about chord progression. They were designed by authors based on our knowledge and experience.

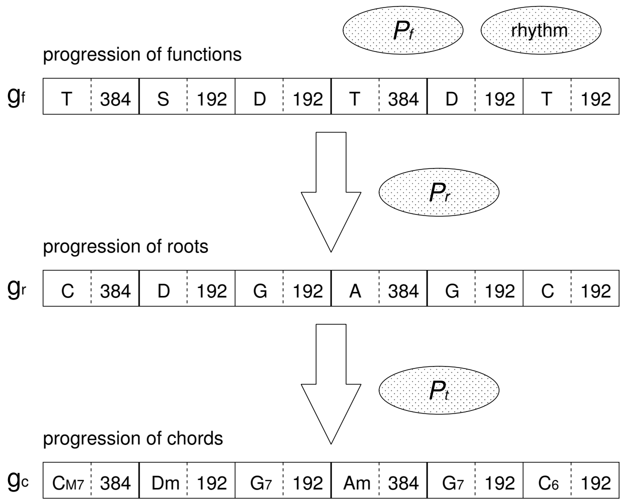

Fig. 4. Initialization of a gene

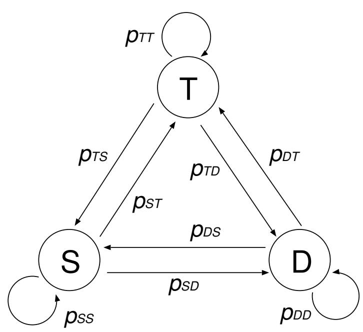

Fig. 5. P_f

Therefore, created chord progressions correspond to music theory. The procedure of the initialization is as follows.

1) A progression of functions is generated by P_f.
2) Each function turns a root of a chord by P_r.
3) A type of each chord is determined by P_t.

Function: Chords are classified into three functions in a chord progression: tonic, dominant and subdominant [6], [7]. Each function has different character. Tonic is the most important function and it has stable sound. A function of the first chord and the last chord of a song is tonic in general. Tonic can proceed to any function. Dominant has unstable sound and it proceeds to tonic strongly. Subdominant has mild tension and it proceeds to tonic or dominant. It can be said that a chord progression is a progression of functions. Hence, progression of functions is generated first in order to create chord progression. The first function and the last function are tonic. Functions subsequent to the first function are determined by P_f. As shown in Fig.5, P_f is a set of probabilities that models a likelihood that a function proceeds to other functions. For example, p_{DT} is the probability that dominant proceeds to tonic. P_f varies based on the value of C. If C is small, P_f is common probability of progression.

Root: A root is the base note of a chord; a chord is

TABLE II

DIATONIC CHORDS OF FOUR NOTES IN C MAJOR

	Tonic	Dominant	Subdominant
main chord	C_{M7}, C_6	G_7	F_{M7}, F_6
substitute chord	Em_7, Am_7		Dm_7

TABLE III

DIATONIC CHORDS OF FOUR NOTES IN A MINOR

	Tonic	Dominant	Subdominant
main chord	Am_7, Am_{M7}, Am_6	E_7	Dm_7
substitute chord	C_{M7}, F_{M7}, $F\sharp m_7^{(\flat 5)}$	$G\sharp_{dim}$	$Bm_7^{(\flat 5)}$, G_7

constructed on a root [6], [7]. After a progression of functions were generated, each function turns a root of each chord by P_r. P_r is a set of probabilities that models a function turns a root. P_r varies based on the value of C.

Type: There are many types of chords [6], [7]. The type of a chord is determined by its notes contained. Each type has different tone. For example, major chords have bright sound and minor chords have gloomy sound. Available chords in a chord progression are determined by its key. Diatonic chords that are constructed with three or four notes are mainly used in the system. Diatonic chords are made from notes of a key and they are able to be used in the key. Tables II and III show diatonic chords that are constructed with four notes in C major and A minor. The type of each chord is determined by P_t. P_t is a set of probabilities that models a likelihood that each type is selected by a root. P_t varies based on the value of C. If C is small, chords tend to have simple type. The more C increases, the more complex types will be selected.

C. Genetic Algorithm

This chapter explains genetic algorithm used in the proposed system.

Fitness: After the user evaluated individual chord progressions, the system creates the next generation with genetic algorithm based on the feedback from the user. Fitness of an individual is the point which the user scores to it. As shown in Table IV, the user evaluates each chord progression on a scale of 1 to 5.

Selection: Linear ranking selection is used for selection. In linear ranking selection, the number of an individual reproduced is based on its ranking. This method can select and reproduce good individuals even if the population size is small.

Crossover: Fig.6 shows an example of crossover used in the system. One-point crossover is used. Crossover interchanges

TABLE IV

EVALUATION OF A CHORD PROGRESSION

1	2	3	4	5
Very bad	Bad	Even	Good	Very good

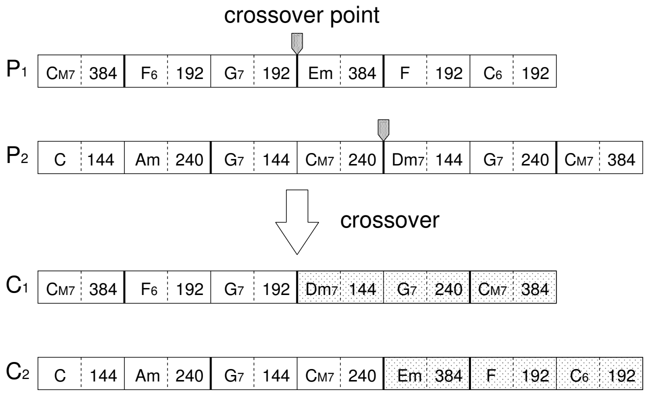

Fig. 6. Crossover

chords of two individuals from the crossover point to the end. Individuals that perform crossover are selected randomly based on crossover rate. Crossover point is confined to a break between two bars (bold lines in Fig.6). This is because total lengths of two chord progressions differ from each other if they have different rhythm patterns and the crossover point is in a bar.

Mutation: Mutation changes a chord to another chord. The procedure to determine a new chord is similar to the initialization of a gene. First, the function of a chord changes other function randomly. Next, the root and the type of the chord is determined by P_r and P_t. When a chord mutates, relation to chords that are located before and after the mutated chord is not considered. Therefore, it is possible that chord progressions which the user can't think of is created.

III. Experiments

We carried out experiments in order to confirm the availability of the system. Table V shows the parameters used in the experiments. These parameters were determined based on pre-experiments. The number of subjects is fifteen. The impressions of chord progressions for input were determined by subjects freely. If there are two or more individuals that a subject evaluates as 5 in the same generation, a piece of creation is finished. Subjects created chord progressions five times using different inputs.

TABLE V
PARAMETERS IN THE EXPERIMENT

Parameter	Value
Population size	10
Crossover rate	0.9
Mutation rate	0.1

A. Results

Table VI shows the experimental results. Each value is an average of all subjects. "Time" is the time that was spent in a piece of creation. "Generation" is the generation at which a piece of creation was finished. "Diversity" and "Tiredness" were evaluated by subjects on a scale of 1 to 5 subjectively. "Diversity" is the variety of created chord progressions through five times. 5 denotes that created chord progressions had good diversity and 1 denotes that they didn't have diversity. "Tiredness" is the fatigue of a subject by using the system. 5 denotes that the subject was tired and 1 denotes that he/she was not tired.

Good chord progressions were obtained in early generations. It is considered that the first generation is generated not randomly but reflecting the user's input. According to the value of diversity, the system can create various chord progressions.

TABLE VI
EXPERIMENTAL RESULTS

	Average value
Time (minute)	8.7
Generation	3.4
Diversity	4.4
Tiredness	3.4

Table VII shows a comparison with chord progressions of famous songs. These songs are popular music in various genres. A chord progression that is a part of a song was used for a comparison. These values were evaluated by subjects on a scale of 1 to 5 subjectively. 5 denotes that created chord progressions are better and 1 denotes that they are worse than chord progressions of the songs.

The results are somewhat low. These chord progressions of the songs were created considering the entire flow well. The system doesn't consider the entire flow. It will be the reason of the results.

TABLE VII
COMPARISON WITH CHORD PROGRESSIONS OF FAMOUS SONGS

Object of comparison	Average value
Canon in D (J.Pachelbel)	2.0
Let It Be (THE BEATLES)	2.6
Stairway to Heaven (LED ZEPPELIN)	2.3
Nagoriyuki (Iruka)	2.6
Kandagawa (Kosetsu Minami)	2.2

B. Examples of created chord progression

Figs.7-10 show examples of created chord progressions through the experiments.

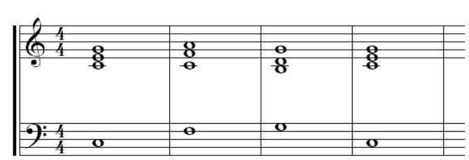

Fig. 7. Brightness = 1, Complexity = -4, Intensity = -4, Generation = 2

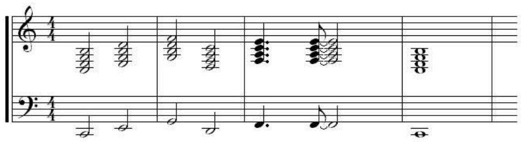

Fig. 8. Brightness = 1, Complexity = 0, Intensity = 2, Generation = 4

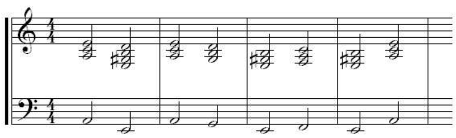

Fig. 9. Brightness = -1, Complexity = -3, Intensity = 1, Generation = 3

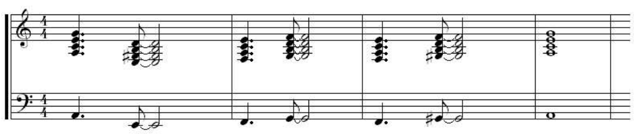

Fig. 10. Brightness = -1, Complexity = 0, Intensity = 3, Generation = 3

IV. Conclusion

In this paper, a chord progression creating system reflecting user's Kansei has been proposed. The proposed system creates chord progressions by interactive genetic algorithm in order to reflect individual Kansei. By using the system, the user who doesn't have the knowledge of music can easily create various chord progressions that meet his/her Kansei. Furthermore, chord progressions are created in a short time.

As a future work, we intend to investigate the relation between chord progressions and Kansei more thoroughly. And we should improve the system to create more musical and more various chord progressions.

V. Acknowledgment

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