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Automatic Melody Generation considering Chord Progression using Genetic Algorithm

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Abstract—In this paper, we propose an automatic melody generation system considering chord progression. In the proposed system, chord progression and rhythm sequence are generated randomly, and the pitch is assigned to each note using genetic algorithm. We carried out a series of computer experiments, and we confirmed that melodies can be generated by the proposed system.

1. Introduction

Since the first approach to the automatic composition in 1957, a lot of methods for automatic composition have been proposed[1]–[6]. As one of these methods, we have proposed the automatic melody generation method using N-gram model and genetic algorithm[5]. In this method, the features on sample melodies are trained using N-gram models[8] per melody blocks such as verse, bridge and chorus. And melodies that have similar features to trained sample melodies can be generated using genetic algorithm[7]. However, in most of these systems, melodies are generated based on a sample melody or sample melodies given by users.

In this paper, we propose an automatic melody generation system considering chord progression. In the proposed system, chord progression and rhythm sequence are generated randomly, and the pitch is assigned to each note using genetic algorithm.

2. Automatic Melody Generation System considering Chord Progression by Genetic Algorithm

Here, the proposed automatic melody generation system considering chord progression by genetic algorithm is explained.

The proposed system has four phases; (1) condition input, (2) chord progression generation, (3) rhythm sequence generation and (4) pitch assignment by genetic algorithm.

2.1. Condition Input

First, a user input following conditions.

- The length of note used mainly is chosen from quarter note and eighth note, or eighth note or sixteenth note.
- Key is selected.
- The length of each section is selected from 4, 8 or 16 bars.
- Whether auftakt is used or not is selected.
- The distribution of difference between two sounds are determined.

2.2. Chord Progression Generation

2.2.1. *Motif Transition*

In the proposed system, each motif consist of two bars. First, motif transition are determined.

If a motif has four bars, motif transition is selected from

- motif A → motif A
- motif A → motif B

randomly.

If a motif has eight bars, motif transition is selected from

- motif A → motif A → motif A → motif A
- motif A → motif A → motif A → motif B
- motif A → motif B → motif A → motif B
- motif A → motif A → motif B → motif B
- motif A → motif A → motif B → motif C
- motif A → motif B → motif A → motif C

randomly. If a motif has 16 bars, motif transition for eight bars are repeated twice.

2.2.2. *Chord Progression Generation*

Next, chord progression is generated randomly. In the proposed system, only diatonic chords (I ~ VI) are used. Based on the rule shown in Table 1, chord progression in each motif is generated randomly. Last chord is selected from tonic chord.

2.3. Rhythm Sequence Generation

The rhythm sequence generation process has two phases; (1) generation of rhythm for basic motif and (2) generation of rhythm for derivation motif.

Table 1: Chord Progression Rule

		To					
		I	II	III	IV	V	VI
From	I	OK	OK	OK	OK	OK	OK
	II	NG	OK	OK	OK	OK	OK
	III	NG	NG	OK	OK	NG	OK
	IV	OK	OK	OK	OK	OK	OK
	V	OK	NG	OK	NG	OK	OK
	VI	NG	OK	OK	OK	OK	OK

(1) Generation of Rhythm for Basic Motif Rhythm for basis motif are generated randomly. If a note which is used mainly is quarter note and eighth note, quarter note or eighth note + eighth note are selected randomly. If a note which is used mainly is eighth note or sixteenth note, eighth note or sixteenth note + sixteenth note are selected randomly. And then, rhythm which including rest (for example, eighth note + eighth rest) are assigned to the last of motif if needed. Moreover, triplet and dotted note is assigned if needed.

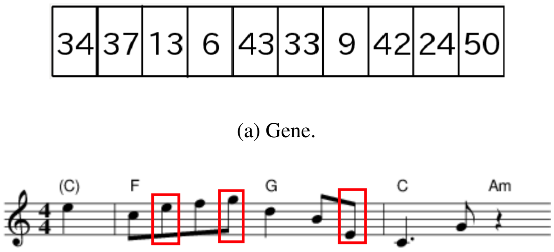
(2) Generation of Rhythm for Derivation Motif Rhythm for derivation motif are generated based on derivation. In each motif, one block (one beat) is selected randomly, different rhythm pattern is assigned. For example, quarter note is replaced by eighth note + eighth note.

2.4. Pitch Assignment by Genetic Algorithm

Based generated chord progression and rhythm sequence, pitch is assigned by genetic algorithm.

2.4.1. Flow of Pitch Assignment

Step 1 : Initial Population Generation In the proposed system, initial individuals are generated randomly.
Step 2 : Fitness Calculation The fitness of each individual is calculated. In the proposed system, the fitness of the gene is calculated based on (1) pitch difference between two sounds, (2) successive non-harmonic tones, (3) successive disjunct motion over four degree and (4) last tone.
Step 3 : Selection
Based on fitness calculated in **Step 2**, individuals used in **Step 4** (crossover) are selected by the roulette selection and the elite preserve strategy.
Step 4 : Crossover
New individuals are generated from the parents which are selected in **Step 3** by the multi-point crossover.
Step 5 : Mutation
In order to maintain genetic diversity, the mutation is carried out.
Step 6 : Repeat
Steps 2 ~ **5** are repeated T_{max} times.



(a) Gene.

(b) Corresponding Melody.

Figure 1: Gene Expression (Basic Motif).

Table 2: Gene Expression (Basic Motif).

	Chord	Candidate						
		0	1	2	3	4	5	
1	C	C_3	E_3	G_3	C_4	E_4		34 mod 5
2	F	A_3	C_4	F_4	A_4			37 mod 4
3	F	G_3	B_3	D_4	E_4	G_4		13 mod 5
4	F	A_3	C_4	F_4	A_4			6 mod 4
5	F	B_3	D_4	E_4	G_4	B_4		43 mod 5
6	G	D_4	G_4	B_4				33 mod 3
7	G	G_3	B_3	D_4	G_4			9 mod 4
8	G	E_3	F_3	A_3	C_4	E_4	F_4	42 mod 6
9	C	C_3	E_3	G_3				24 mod 3
10	C	C_3	E_3	G_3				50 mod 3

2.4.2. Gene Expression

In the proposed system, pitches for basic motif are expressed as gene. For derivation motif, variation rule are expressed as gene. For basic motif, each part in a gene takes 0~59, and the value divided by the number of pitch candidates means the pitch. For derivation motif, each part in a gene takes rule index.

Figure 1 shows an example of gene and corresponding melody. In Fig.1, red rectangle shows non-harmonic tone selected randomly. Table 2 shows a decision process from gene expression to corresponding melody.

2.4.3. Fitness

(1) Pitch Difference between Two Sounds

In the proposed system, the fitness on pitch difference between two sounds of the gene p, $V_{TD}(p)$ is calculated by

$$V_{TD}(p) = \frac{1}{N^m} \sum_{m=1}^{N^m} (1 - D_{JS}(P^{m(p)} || P^{m(i)})) \quad (1)$$

where N^m is the number of motifs. $D_{JS}(P^{m(p)}||P^{m(i)})$ is JS (Jensen–Shannon) divergence between pitch difference in the motif m given by gene p $P^{m(p)}$ and pitch difference distribution given by user $P^{m(i)}$, and it is given by

$$D_{JS}(P^{m(p)}||P^{(i)}) = \frac{1}{2} D_{KL}(P^{m(p)}||P^{m(p,i)}) + \frac{1}{2} D_{KL}(P^{m(i)})||P^{m(p,i)}) \quad (2)$$

where $P^{m(p)}$ is the average of $P^{m(p)}$ と $P^{m(i)}$ and it is given by

$$P^{m(p,i)} = \frac{1}{2}(P^{m(p)} + P^{m(i)}). \quad (3)$$

$D_{KL}(P^{m(p)}||P^{m(p,i)})$ and $D_{KL}(P^{m(i)}||P^{m(p,i)})$ are KL (Kullback–Leibler) divergence $P^{m(p)}$ and $P^{m(p,i)}$ and $P^{m(i)}$ and $P^{m(p,i)}$, and they are given by

$$D_{KL}(P^{m(p)}||P^{m(p,i)}) = \sum_{j=1}^{N^D}\left(P_j^{m(p)} \log_2 \frac{P_j^{m(p)}}{P_j^{m(p,i)}}\right) \quad (4)$$

$$D_{KL}(P^{m(i)}||P^{m(p,i)}) = \sum_{j=1}^{N^D}\left(P_j^{m(i)} \log_2 \frac{P_j^{m(i)}}{P_j^{m(p,i)}}\right) \quad (5)$$

If $P_j^{m(p)}$=0 or $P_j^{m(p,i)}$=0, they are given by

$$P_j^{m(p)} \log_2 \frac{P_j^{m(p)}}{P_j^{m(p,i)}} = 0. \quad (6)$$

If $P_j^{m(i)} = 0$ or $P_j^{m(p,i)} = 0$,

$$P_j^{m(i)} \log_2 \frac{P_j^{m(i)}}{P_j^{m(p,i)}} = 0. \quad (7)$$

In Eqs.(4), (5), N^D is the number of categories of pitch difference, in the proposed system, $j = 1$ means 1st, $j = 2$ means 2nd, $j = 3$ means 3rd or 4th, $j = 4$ means 5th, $j =$ means over 5th, and so $N^D = 5$.

JS divergence becomes 0 when two distributions are same.

(2) Successive Non-Harmonic Tones

The fitness on successive non-harmonic tones of the gene p, $V_{NC}(p)$ is given by

$$V_{NC}(p) = \frac{1}{N^m}\sum_{m=1}^{N^m} f_{NC}(N_{NC}^m(p)) \quad (8)$$

$$f_{NC}(u) = \begin{cases} 1 & (u = 0) \\ 0 & (\text{otherwise}) \end{cases} \quad (9)$$

where $N_{NC}^m(p)$ is the number of successive non-harmonic tones in the motif m of melody given by the gene p.

2.4.4. (3) Successive Disjunct Motion over Fourth

The fitness on successive disjunct motion over 4th of the gene p, $V_{SK}(p)$ is given by

$$V_{SK}(p) = \frac{1}{N^m}\sum_{m=1}^{N^m} f_{SK}(N_{SK}^{m(p)}) \quad (10)$$

$$f_{SK}(u) = \begin{cases} 1 & (u = 0) \\ 0 & (\text{otherwise}) \end{cases} \quad (11)$$

where $N_{SK}^{m(p)}$ is the number of successive disjunct motions over 4th in the motif m of the melody given by the gene p.

(4) Last Tone

The fitness on last tone of the gene p, $V_{LT}(p)$ is calculated by

$$V_{LT}(p) = \begin{cases} 1 & (iflastsoundisroot) \\ 0.5 & (iflastsoundisharmonictone) \\ 0 & (iflastsoundisnon-harmonictone) \end{cases} \quad (12)$$

(5) Total Fitness

Total fitness is calculated by

$$V(p) = V_{NC}(p) + 0.6 \times 10^{-10} \times \exp(V_{TD}(p) \times 23.65) + V_{SK}(p) + V_{LT}(p) \quad (13)$$

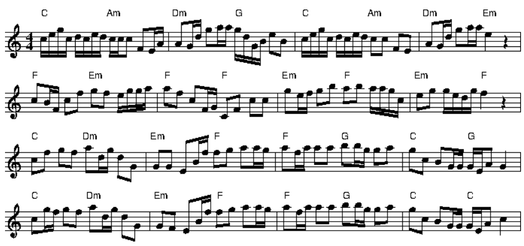
3. Computer Experiment Results

Here, we show the computer experiment results to demonstrate of the effectiveness of the proposed system.

Figure 2 shows examples of generated melodies.

Figure 3 shows the fitness transition.

(a)



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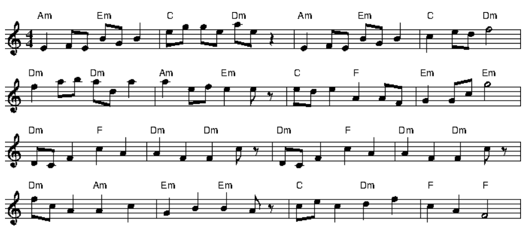
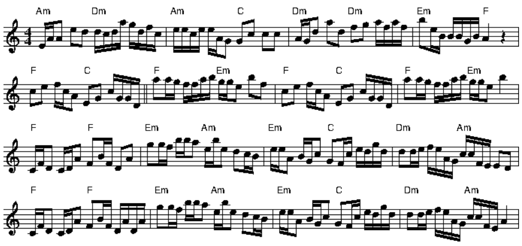


(c)



(d)

(e)

(f)

Figure 2: Examples of Generated Melodies.

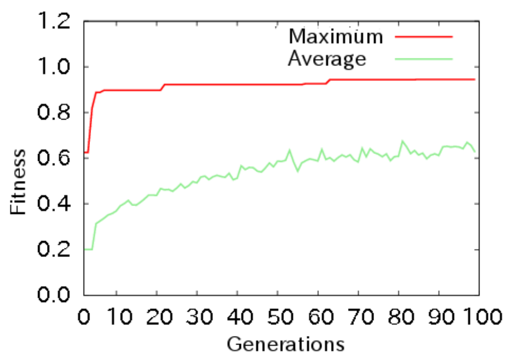


Figure 3: Fitness Transition.

4. Conclusions

In this paper, we have proposed the automatic melody generation system considering chord progression. In the proposed system, chord progression and rhythm sequence are generated randomly, and the pitch is assigned to each note using genetic algorithm. We carried out a series of computer experiments, and we confirmed that melodies can be generated by the proposed system.

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