Melody Composition Using Geometric Crossover for Variable-length Encoding

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ABSTRACT

This paper proposes a system that uses interactive genetic algorithm (IGA) to automatically compose songs according to the userfis preferences. As notes have duration and pitch, the number of notes within a measure is subject to change. Geometric crossover can be used to make offspring notes while preserving the positive characteristics within such variable-length sequences. The proposed automatic composition system uses geometric crossover in IGA to produce songs customized to the user. Experimental results indicate that the proposed system effectively generates new notes from variable-length note sequences within a single measure.

CCS CONCEPTS

•**DETA - Digital Entertainment Technologies and Arts** → **Biologically-inspired creativity;** *Artificial creative agents;*

KEYWORDS

Genetic algorithm, automatic composing, geometric crossover

1 INTRODUCTION

Artificial intelligence (AI) has made significant advancement over the past half century. Alpha-Go, made based on deep-learning, has defeated the worldfis top Go player, and AI also surpassed human capability at the ImageNet Large Scale Visual Recognition Competition (ILSVRC) [3]. However, in the arts field, and especially in the creation process, AI is yet to surpass the capabilities of human beings. Art is humanityfis expression of things that are perceived as beautiful. However, considering that the standard of beauty is different for every individual and organization, it is difficult to express whether a work is good or bad in objective terms. A standard for a good melody is not defined mathematically, and individuals have different criteria. In an effort to address this problem, this paper proposes a method for calculating evaluation scores customized to users using interactive genetic algorithm (IGA) and a chord table. Crossover is the most crucial calculation within GA when creating new generations. However, as the number of notes within a measure is subject to change, using the general crossover method can lead to unwanted loss. Therefore, the system proposed in this paper uses geometric crossover, which can deal with variable-lengths,

enabling it to effectively produce new generations regardless of the number of notes.

2 RELATED WORK

Automatic composition using GA was first proposed by Honer and Goldberg [4]. Subsequently, Biles [1] developed an effective system that creates jazz solos based on IGA. The developed system made notes with scales that match the chord and calculated evaluation scores based on interaction with users. The duration was set by encoding notes with a pitch of zero as rests. Single-point crossover was employed. As a result, good jazz solo melody lines were created. The quality of the melody produced in studies that employed methods other than IGA, such as by Gartland-Jones *et al.* [2] and Matic [5], was evaluated as poor. Moraglio *et al.* [6] proposed geometric crossover for biological sequences, which comprise variable-length DNA. The method effectively helped to recombine chromosomes of different lengths.

3 REPRESENTATION AND GEOMETRIC CROSSOVER

A chromosome expresses a single measure within a score. For music with 16 measures, 16 chromosomes are used. Each chromosome also contains chord information, as it deals with music composition. The notes that constitute a measure have both pitch and duration. The most representative method for expressing this is to use any note whose pitch is zero as a connecting sound of the previous note or treat it as a rest. The major benefit of this method is that crossover calculation can be performed in a simple manner as the length of the chromosome is consistent and there is a wide range to choose from. Using the traditional *n*-point crossover inappropriately, however, can destroy the note in the middle of the sound, and thus can be disadvantageous when trying to preserve good sound arrangements. The method proposed in this paper expresses diverse notes that have both pitch and duration. Using such notes, the length of the chromosome constituting a note is subject to change according to its duration, as depicted in Figure 1.

Figure 1: Representation of chromosome

Using geometric crossover [7], it is possible to receive a lot of common genes of parents. In spite of the different lengths, this enables the good characteristics of the notes to be preserved while combining them. The duration of the notes that constitute the newly produced chromosome may either be longer or shorter than the length of a single measure. When it is longer than the length of a measure, the notes can either be shortened randomly or deleted. Conversely, when it is shorter, the notes can either by lengthened randomly or random notes can be added. This process is repeated until it can become a standard duration for a single measure. The length of the standard duration depicted in Figure 1 is 16. This process is illustrated in Figure 2.
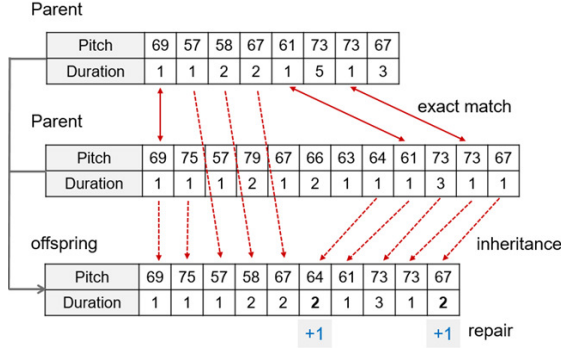

Figure 2: An example of crossover

4 FITNESS EVALUATION

As people have different criteria to assess a good melody, the fitness function cannot be easily defined in research on automatic composition. From the perspective of Harmonics, there is a measurement method that assigns a lower evaluation score when there is a sound that is not included in the chord scale. Even in a good melody, however, there are often sounds that are not a part of the chord scale. Therefore, a more delicate standard that is customized to each user is needed. To this end, in this study, the chord table shown in Figure 3 was created in order to identify the melody that fits a userfis taste in a certain chord.

Figure 3: Score of notes in *Dm* chord

In Figure 3, the score attribute values are scores for notes that are part of the *Dm* Chord. The score of the subsequent note is the

score for the current note when the previous note is the pitch value. On this basis, the score can be expressed as in Equation (1):

$$\left(\sum_{i=1}^{n} Score(Note_i) + nextScore(Note_{i-1}, Note_i) \right) / n, \quad (1)$$

where n is the number of notes encoded within the chromosome, and $Note_i$ refers to the i-th pitch of the note. The chord table presented in Figure 3 is not static, it can be updated in accordance with the userfis evaluation. When the music composed based on the current chord table is evaluated as bad by the user, the scores of the referenced chord table are all reduced. Conversely, when it is evaluated as good, then the referenced chord table scores are all raised. This evaluation process results in a chord table that is customized to the user and can be used for automatic composition.

5 EXPERIMENTS AND DISCUSSION

The authors are developing a melody-composition program that uses IGA with geometric crossover. The latest developments in the program can be viewed online (https://youtu.be/8gJzJiAHv1k). In conclusion, it was confirmed that notes arrangement based on crossover calculation preserve well the positive aspects of the parent notes. When the program is finalized, it is hoped that it will provide more customized music to users by implementing a more sophisticated fitness function based on large-scale experimentation.

Table 1: Genetic parameters

Generation	66
Population size	100
Mutation probability	0.2

Figure 4: A melody found in the 66-th generation

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