Classified-Chime Sound Generation Support System using an Interactive Genetic Algorithm

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Abstract. This research proposes a chime sound generation support system to readily generate intercom chime sounds that are agreeable to individual persons and to associate the chime sounds with visitors. In the proposed system, an interactive genetic algorithm (IGA) is used. Based on the melodies created by users, chime sounds are automatically generated in accordance with rules. The effectiveness of the proposed system is verified by an experiment using the system.

Key words: Optimization, Interactive Genetic Algorithm, Chime sound

1 Introduction

Most information is displayed by visual media in our daily lives. Recently, however, electronic devices are becoming smaller and more portable. The display of visual information is restricted, because the size of visual displays is limited [1]. At the same time, auditory information is not restricted by the display size. Accordingly, it is not necessary to pay attention visually to the object and it is possible to obtain auditory information in a paratactic manner, making information propagation highly effective [2].

In this background, alarms using sound are becoming quite common in home electric appliances. These auditory signals are often monotonous, however and not all users like them. Therefore, it may be useful for users to create their own melodies and use them as auditory signals. In addition, products that identify individuals and classify them into categories using sounds have also increased in recent years. For example, cell phone ringtones can be changed depending on the caller, allowing the user to know who a caller is before answering the phone and deal with the call in an appropriate manner. For intercoms, it is useful to be informed of visitors by sound, as well as be informed of who a visitor is before greeting them.

Visitors can be discriminated by using the latest intercom image processing technology. Therefore, it is useful to compose and set different melodies for individual visitors according to the user's taste, but this is difficult for people who do not know how to compose melody. It may impose a tremendous burden on users to compose multiple chime sounds for visitors.

Therefore, this research proposes a chime sound generation support system that generates chime sounds suiting individual tastes, recalling individual visitors and bearing sounds with information that conveys a message using Interactive Genetic Algorithm (IGA) [3], one of the possible optimization methods. The authors of this paper have already developed a system to generate auditory signals using IGA [4]. This research applies this approach for the generation of auditory signals to the generation of chime sounds for intercoms and further proposes a method to change chimes depending on the visitor category.

2 Interactive Genetic Algorithm

An Interactive Genetic Algorithm (IGA) [3] is a Genetic Algorithm (GA) [5] which simulates evolution of organisms, where the evaluation part of the GA is handled subjectively by a human being. In problems which cannot be numerically quantified because they involve the impressions and tastes of human beings, optimization is done based on evaluation according to human sensibility. IGA is used for "3-D CG Lighting" [6], "Application of fashion design" [7] etc. In this research, the aim is using IGA which allows even ordinary users, who cannot create melodies using musical instruments, to simply create good chime sounds simply by evaluating several candidate solutions based on their own subjectivity. In this research, the aim is to develop a method based on IGA which allows even ordinary users, who cannot create melodies using musical instruments, to simply create good and purposeful sign sounds simply by evaluating several candidate melodies based on their own subjectivity.

3 Chime Sound Generation Support System

3.1 Overview of Chime Sound Generation Support System

This system generates chime sounds matching user tastes by having users evaluate proposed melodies. IGA is used for the method. Furthermore, based on the chime sounds prepared by a user, multiple chime sounds are automatically generated depending on the predetermined visitor category. Fig. 1 shows a conceptual diagram of the system.

3.2 Category Classification

In the preparatory experiment of this system, the appropriateness of the number of visitor categories necessary for the automated generation of melodies and the importance of the visitor discrimination criteria were dealt with. As a result, visitors were categorized into three categories, specifically family members, acquaintances and strangers. For category classification, visitors are classified by face recognition using the a camera in the intercom. Acquaintances are persons other than family members whose faces are registered in advance. Strangers are persons with no face data registered.

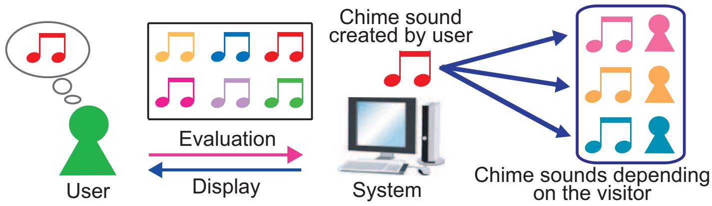

Fig. 1. Conceptual diagram of the chime sound generation support system.

3.3 Method of Representing Sound

The method of representing sound in the proposed system was determined as follows by performing preliminary experiments from various standpoints, and taking those results into consideration. In this system, one melody is expressed as one individual. The notes which constitute a melody are quater note, quater rest, eighth note, and eighth rest. The note length was determined by taking one eighth note to be the basis for one note in this system. The length of the melody was made into 2 bars by 3/4 meter, tempo set to 125 Beats Per Minute, and the tone was taken as Vibraphone. The value expressing a quater note, and the value of note pitch are stored in each gene. Note numbers defined using a Standard MIDI File (SMF) were used to represent tone pitch. In the note numbers in the SMF, 60 is taken to be middle C(C4) on the piano, and the numbers change by 1 for each semi-tone. The lowest tone is defined to be 0, and the highest tone is defined to be 127. The note numbers used in the research were selected from the C major scale, from which it is easy to generate melodies with a bright sound, and the range of notes was set to note numbers 60 to 79 only. The rest was defined as 128 which is not used by SMF, and the value expressing a quater note was defined as 129 which is not used by SMF. Fig. 2 shows the relation among tone pitches, note numbers and pitch names, and Fig. 3 shows the chromosome structure.

Fig. 2. Relation among tone pitches, note numbers and pitch names.

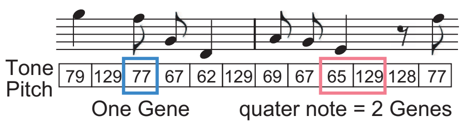

Fig. 3. Chromosome structure.

3.4 Flow of Chime Sound Generation Support System

Fig. 4 shows the flow of melody generation in the system. The processes performed in each block in Fig. 4 are as follows:

1. Generation of initial individuals
   In IGA, optimized individuals are likely to depend on the initial individual.

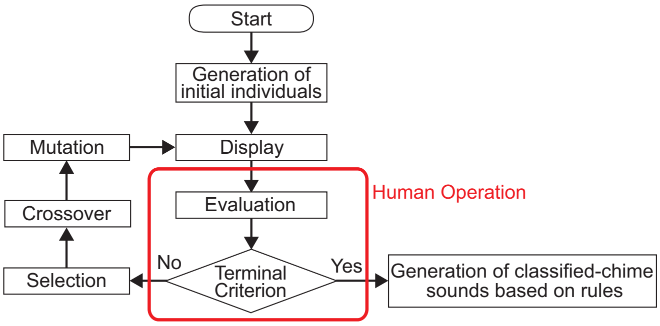

Fig. 4. Flow of chime sound generation support system.

   Therefore, it is important to propose as many initial individuals as possible. In this system, however, the number of individuals proposed at one time is limited. As a result, this system uses the following method to propose as many individuals as possible to users at an earlier stage.
   A user evaluates 12 individuals randomly generated by the system using a five point scale. The system chooses four individuals with higher scores and adds two individuals newly generated in a random manner. The six individuals become the initial individual group. Individuals randomly generated have tone values that are randomly determined within the range of definition.
2. Display
   The system displays individuals as score corresponding to a melody like Fig. 5 to a user. User can listen to melody by pushing Play button.

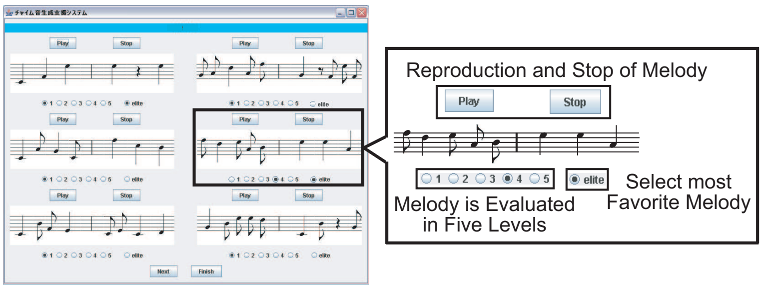

Fig. 5. Display.

3. Evaluation
   The user listens to the melody, and evaluates it with a score of 1 to 5 points. Also, user chooses one individual as the "elite individual".
4. Selection
   The system is performes the designated selection (Roulette Selection and Elite Preservation) based on evaluation conducted by the user.
5. Crossover
   Crossover is performed so that the phrase in a melody may not be destroyed.

Therefore, phrase size was set to one bar, and one-point crossover was performed in phrase units. Fig. 6 shows an example of crossover.

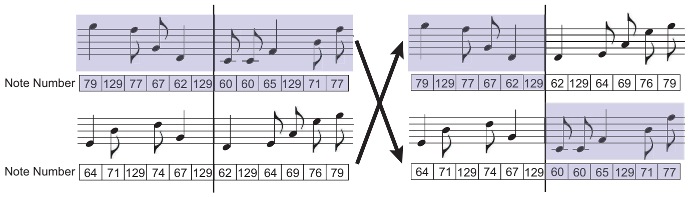

Fig. 6. Crossover.

6. Mutation
   Mutation is performed to tone pitches. When the object of mutation is rest, tone pitch is varied randomly within the defined range. When it is not rest, if variation is done uniformly without designating a range for tone pitch, melody is uncomfortable, and thus variation is done randomly in a range of three steps above or below the height of the original tone.
7. Terminal criterion
   Search is ended when the chime sound which a user satisfies is able to be created. The minimum number of generations is 3 and a maximum is 10.
8. Generation of classified-chime sounds based on rules
   Based on the melodies created by users in operations 1 through 7, three types of melodies are generated based on the rules. A preliminary experiment was performed to determine the appropriateness of the rules for each category.
   – Family members
     The tone of the last three notes of the base melody is increased gradually using the sounds of the primary triads of C major.
   – Acquaintances
     The tones of all the notes in the base melody are unchanged except that they are changed into eighth notes.
   – Strangers
     The primary triads of C minor are used for the tones of the last three sounds of the base melody. The same tones are used for the last note and the third last note, while higher tones are used for the second last note.

   Fig. 7 shows an example of the rules. The frames shown in Fig. 7 indicate the parts changed from the base melody.

4 Evaluation Experiment

4.1 Overview of the Experiment

An experiment was performed to verify the effectiveness of the proposed system. The subjects included 20 males and females in their 20s. In the experiment, the

Fig. 7. Example of the rules.

number of individuals in one generation was set to six, the crossover rate was set to 1.0 and the mutation rate was set to 0.16. In the experiment, subjects were ordered to make chime sounds using the proposed system. After that, a questionnaire was performed regarding items (1) through (3) shown below. Furthermore, subjects were asked to listen to chime sounds generated by the proposed system that varied by visitor and were asked to answer questionnaire items (4) and (5). The system generated melodies for the three categories of family members, acquaintances and strangers. Subjects were blinded to each melody category.

[Questionnaire]

(1) Do you have any knowledge regarding music composition, etc.?
(2) How satisfied are you with the chime sounds generated by the system?
(3) How easy do you think it is to make chime sounds using the system?
(4) Can you guess which melody is for family members, acquaintances and strangers, respectively?
(5) How much do you like each melody?

4.2 Experimental Results and Discussion

Fig. 8 through Fig. 12 show the results of questionnaire items (1) through (5), respectively.

Fig. 8 shows that most of the subjects had no knowledge of music such as composition. Fig. 9 shows that most of the subjects thought that they could satisfactorily compose melodies using the system. Furthermore, in Fig. 10, most of the subjects answered that it was easy to make melodies. As shown above, even persons without knowledge of music could easily make satisfactory melodies.

As shown in Fig. 11, when a melody targeted for "family members" is changed, 55% of subjects determined that the changed melody was for "family members," while 45% of subjects determined that the changed melody was for "acquaintances." Discrimination between "family members" and "acquaintances" was not easy. It is believed that the familiarity of a melody is one element in determining the type of visitor that was different among subjects. Meanwhile, for melodies targeted for "acquaintances" and "strangers" that were changed,

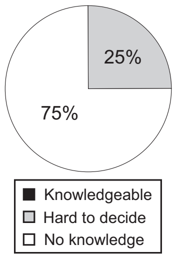

Fig. 8. Result of questionnaire item (1).

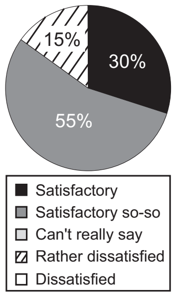

Fig. 9. Result of questionnaire item (2).

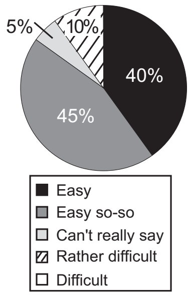

Fig. 10. Result of questionnaire item (3).

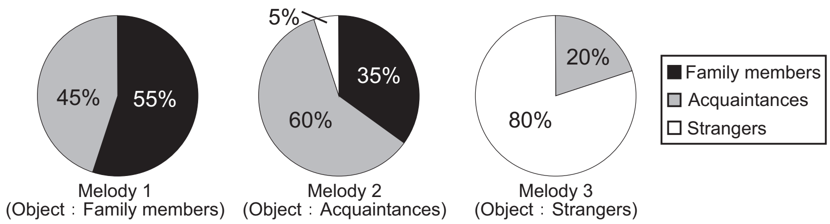

Fig. 11. Result of questionnaire item (4).

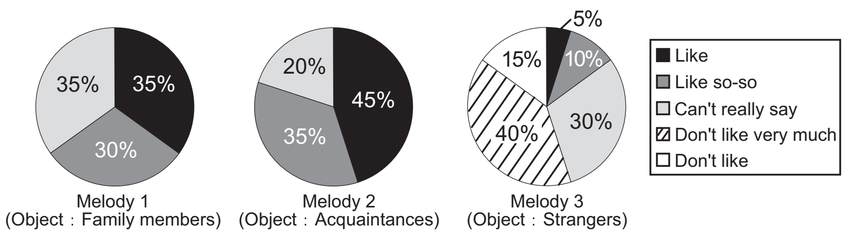

Fig. 12. Result of questionnaire item (5).

more than 60% of subjects correctly determined the discrimination of the melody. It can be said that information that conveys a message was added to the melodies to discriminate visitors based on the rules.

Fig. 12 shows that the favorability rating of changed melodies for "family members" and "acquaintances" was very high. Meanwhile, subjects did not like changed melodies for "strangers." It is believed that the subjects did not like these melodies because the modified characteristics of the melody gave them an uncomfortable feeling.

As shown above, the basic melodies made by the system were satisfactory. Accordingly, rules for the melodies for each visitor category should be improved. Specifically, it is necessary to improve familiarity for melodies for "family members" in order to discriminate between melodies for "family members" and "acquaintances." In respect to "strangers" on the other hand, information that conveys a message in the melody should remain and the rules for changing the melodies should be reviewed so that the melodies for "strangers" better suit user tastes.

5 Conclusion

In this research, a chime sound generation support system where favorite chime sounds can be created for an intercom and automatically generated depending on the category of visitor was constructed. The evaluation experiment showed that even users who had no knowledge about music could make satisfactory chime sounds easily by using the proposed system. In addition, it showed that melodies with information that conveys a message could be made for acquaintances and strangers and melodies for family members and acquaintances that highly suit the subjects' taste could be generated by the system based on the proposed rules.

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