A Proposal for Optimization Method of Vibration Pattern of Mobile Device with Interactive Genetic Algorithm

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Abstract. The vibration patterns are often used in mobile devices such as cellular phone, tablet computer and smartphone, etc. However, these vibration patterns are ready-made patterns. Most of the users do NOT use vibration pattern suited to each user's preference and objectives to use. Interactive Evolutionary Computation (IEC) was known as effective method to create contents suited to each user, and IEC was applied for creating various media contents. This study proposes an Interactive Genetic Algorithm (IGA) creating vibration pattern. Although some previous IEC studies have tried to optimize media content related to sense of touch, an IEC method optimizing vibration pattern of mobile device have not been proposed. The proposed method will dedicate to use of the vibration pattern by improving its ability of notice and/or by enhancing its suitableness in preference.

Keywords: Interactive Evolutionary Computation, Preference, Vibration Pattern, Genetic Algorithm.

1 Introduction

Recently, we use various types of media contents in various situations. We enjoy these media contents, furthermore, some of them dedicate to change atmosphere. To utilize the media contents, it is ideal that each of the users obtain the media contents suited to each user's preference. However, it is still difficult to obtain the media contents, because preference of the users is very different and complex.

Interactive Evolutionary Computation (IEC) was known as an effective method to create contents suited to each user, and IEC was applied for creating various media contents [1]. Most of IEC applications were related to sense of sight such as image, movie, and graphics [1, 2]. Music and sound were next candidates of IEC applications. In recent years, with helps of development of information technology, the area of IEC applications were spread to various fields related to other human senses such as taste [3], smell [4], and touch [5, 6].

This study focuses our attention on the creation of vibration pattern. The vibration patterns are often used in mobile devices such as cellular phone, tablet computer and smartphone, etc. However, these vibration patterns are ready-made patterns: Most of

A. Marcus (Ed.): DUXU/HCII 2013, Part III, LNCS 8014, pp. 264–269, 2013.
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the users do NOT use vibration pattern suited to each user's preference and objectives to use.

This study proposes an IEC creating vibration pattern suited to each user. Although some previous IEC studies have tried to optimize media content related to sense of touch [5, 6], an IEC method optimizing vibration pattern of mobile device have not been proposed. The proposed method will dedicate to use of the vibration pattern by improving its ability of notice and/or by enhancing its suitableness in preference. Furthermore, this study investigates the efficacy of the proposed IEC method through experiment.

2 Proposed Method: IEC for Vibration Pattern

Evolutionary Computation (EC) is used for optimizing several variables suited to certain problem. In other words, EC searches best combination of several variables for the problem. IEC is an interactive type of EC by using human as a function of problem.

Generally, vibration pattern used in cellular phone is composed of on- and off- vibrations. In the proposed method, individual (solution candidate) in IEC is designed as combination of successive several time lengths of vibration and non-vibration (Fig. 1). In this example, number of variables (dimension) of the optimization problem is six. The strengths of the vibrations were set in equal.

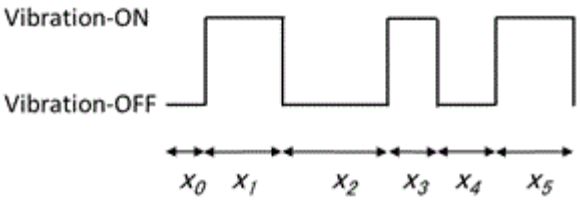

Fig. 1. Correspondence between vibration pattern and values in GA individual

3 Experiment

To investigate the efficacy of the proposed method, two types of experiment was conducted with a vibration device based on the proposed method. In the first experiment optimizing vibration pattern, vibration patterns were created based on the proposed method. To have precise comparison between initial (randomized) vibration pattern and optimized vibration patterns, representative vibration patterns were directly compared in the re-evaluating experiment (Fig. 2).

3.1 Experiment 1: Optimization of Vibration Pattern

To create the vibration patterns based on the proposed method, creating experiment was conducted. In the creating experiment, the vibration pattern was presented by the system based on the proposed method. Nineteen males participated in the experiment

as the subjects. The subjects evaluated the vibration patterns created from the system continuously in 7-point scale (1: Extremely dislike – 7: Extremely like).

Genetic Algorithm (GA) [7, 8], the most popular evolutionary algorithm, was employed as evolutionary algorithm in the system. Interactive type of GA is called as Interactive Genetic Algorithm (IGA). An IGA system with a mock-up of cellular phone based on the proposed method was constructed. The vibration pattern was composed of six time lengths of on and off vibrations (Fig. 1). Set of GA parameters were as follows:

Generation: 10
Number of individuals: 8
Selection: Roulette shuffle selection
Crossover: 1-point crossover, 90%
Mutation: 5%

3.2 Experiment 2: Re-evaluation of Optimized Vibration Patterns

The same nineteen subjects participated in the experiment 2, the re-evaluating experiment. The re-evaluating experiment was conducted after the experiment 1 at least on day. The subjects evaluated only four vibration patterns: these four patterns were representative patterns picked up from the experiment 1: best pattern in each of the 1st, 4th, 7th, and 10th generations. The subjects evaluated these four vibration patterns in 7-point scale as same as the experiment 1.

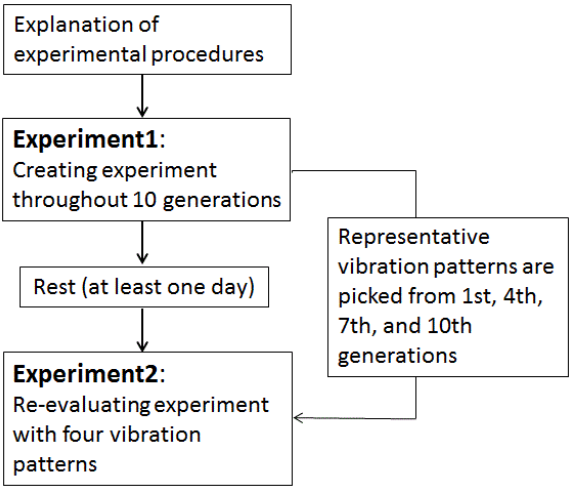

Fig. 2. Experimental Procedure

4 Experimental Results

Fig. 3 shows progress of fitness values in the experiment 1. Once progress of maximum and mean fitness values were obtained in each of the subjects, average of them were calculated.

The lowest fitness values were observed in the 1st generation in both of maximum and mean. Through the fluctuated state, the maximum and mean fitness value reached to the highest in the 10th generation, respectively. The difference of the highest and the lowest fitness in average fitness was smaller than 1 point.

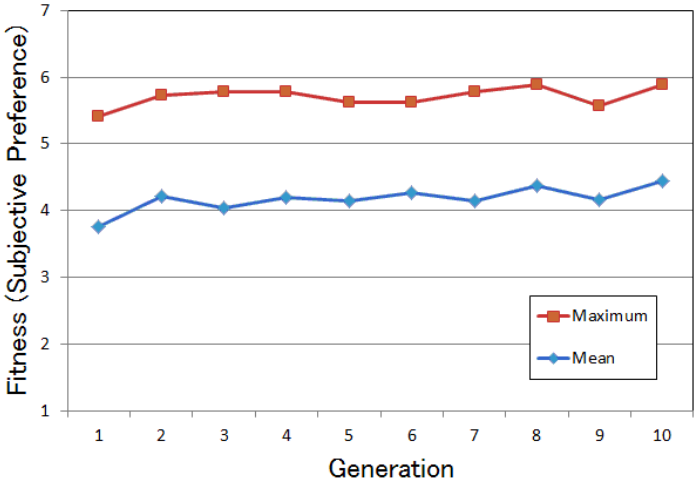

Fig. 3. Progress of maximum and average fitness values in the creating experiment

Fig. 4 shows progress of average fitness values and its standard deviation in the experiment 2, re-evaluating experiment. The lowest fitness value was observed in the 1st generation. The fitness value obviously increased from the 1st generation to the 4th generation. However, the increase stopped and the fitness value keeps it level to the 10th generation.

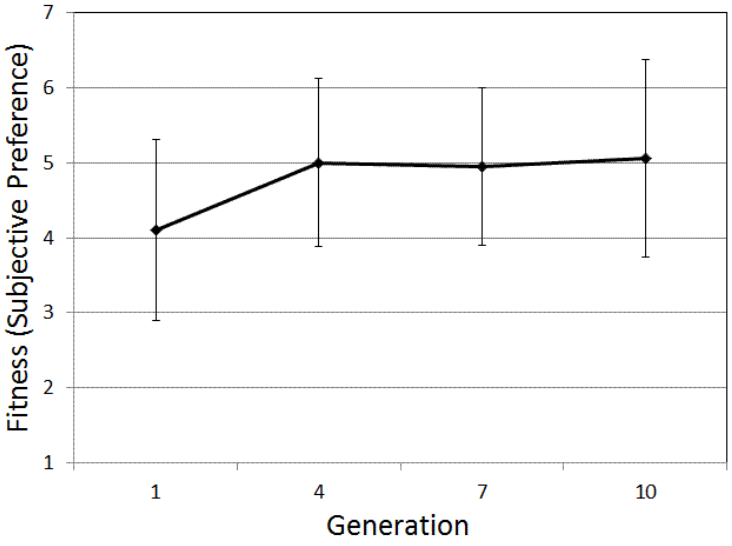

Fig. 4. Progress of average fitness value and its standard deviation in the re-evaluating experiment

5 Discussion and Conclusion

The results of the experiments showed the increase of the fitness value in accordance with the progress of generation. This means the vibration patterns was improved and was optimized to the subject's preference. However, the increase of the fitness value was not large and was not significant.

The reason why the proposed method did not show the significant increase might be caused from set of IGA. Ten generation is relatively short as evaluation time in evolutionary algorithm, however, it is difficult for human to evaluate the patterns through large number of generations. Therefore, other evolutionary algorithm such as Differential Evolution (DE) [10, 11] having effective search ability should be employed in the proposed method. DE was already applied for IEC as Interactive Differential Evolution (IDE) with human user [4, 12].

The reason above must be related to the evaluation method. It was hard for the subject to evaluate precisely many vibration patterns continuously. To solve the problem, we are planning to have another experiment that the subjects can evaluate the vibration patterns easily and precisely. Furthermore, the proposed IGA method should be improved its design to create more various vibration patterns.

Acknowledgements. This work was supported in part by Ministry of Education, Culture, Sports, Science and Technology, Grant-in-Aid for Young Scientists (B) and Grant from Computer Science Laboratory, Fukuoka Institute of Technology.

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