Interactive Evolutionary Computation Using Multiple Users' Gaze Information

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Abstract. We propose an interactive evolutionary computation (IEC) method that uses the gaze information of multiple users to reduce user evaluation loads. The IEC method employs user sensitivity to evaluate candidate solutions of evolutionary computation. However, IEC has a problem that user evaluation loads of candidate solutions are large. To solve this problem, some researchers have proposed various methods using a simple evaluation of candidate solutions or biological information. Therefore, we use the gaze information of users to evaluate candidate solutions in IEC. By using gaze information, the system can reduce the user evaluation load without the need for users to wear a special measuring device. We created a women's clothing coordination system using IEC with gaze information. We conducted an evaluation experiment to verify the effectiveness of the proposed system. The experimental results show that the proposed system is effective for incorporating users' gaze information into IEC evaluation.

1 Introduction

Interactive evolutionary computation (IEC) is a method that uses human sensibilities to evaluate candidate solutions of evolutionary computation (EC). Therefore, IEC is effective for problems that emphasize human sensitivities [1]. First, the IEC randomly generates an initial population of a predetermined number of individuals. Next, it presents the generated individual to the user, who evaluates it. The user evaluates to the presented individual. Next, the IEC performs an EC based on the user evaluation and presents the newly generated individual again. The IEC repeats these processes until a solution that satisfies the user is obtained.

Because IEC can employ human sensibility, it has been applied in a wide range of fields such as art, engineering, education, and games [1]. Some researchers confirmed the effectiveness of IEC in various fields such as music composition [2] and hearing aid fitting [3]. In addition, some researchers have proposed method in which multiple users evaluate the candidate solutions of IEC [4]. However, IEC has the problem that user evaluation loads of the candidate solutions are large.

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To solve this problem, some researchers have proposed using human biometric information for the IEC evaluation. Biometric information includes heart rate [5], brain function, and gaze information [6]. However, to acquire heart rate and brain function information, the users must wear a measurement device. This is a user loads. In contrast, gaze information can be measured with a non-contact type measuring device, that does not impose a user loads. Therefore, we measure gaze information using a non-contact type measuring device.

We propose an IEC system that employs multiple user gaze information for evaluating candidate solutions. We aim to reduce the user load using gaze information with a non-contact measuring device. In addition, when multiple users evaluate in IEC, we consider that these evaluations can easily be obtained using gaze information because the system uses the gaze information instead of the evaluation of each user to obtain the final evaluation value.

The system uses women's clothing to make users interested. We performed an evaluation experiment with real users to verify the effectiveness of the proposed system. The results verify the effectiveness of using gaze information to evaluate IEC.

2 Proposed System

2.1 Summary of the Proposed System

In this study, we proposed a female clothing coordination generation system that evaluates solution candidates using the gaze information of multiple users. Figure 1 shows an outline of the proposed system.

First, the system generates an initial population and presents it to the user. The user is presented with two different of clothing coordination. The system evaluates the presented individuals using gaze information. Based on the evaluation, the system performs EC and generates new clothing coordination.

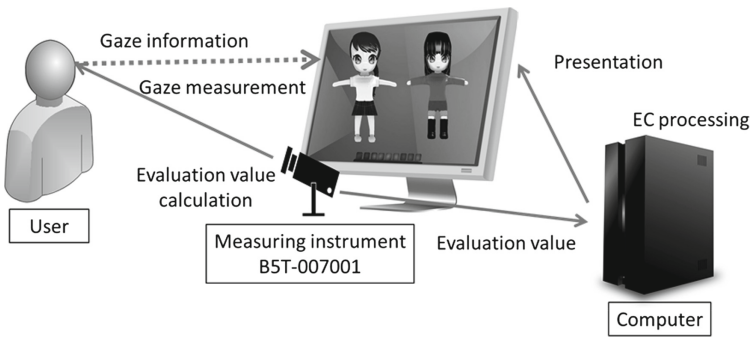

Fig. 1. Outline of the proposed system

The system presents the new individuals to the user, who again evaluates them. The system repeats this process until a solution that satisfies the user is obtained.

In the proposed system, to acquire the user's gaze accurately, the system determines which side of the screen the user is looking at. In addition, to maintain the user's interest, the system retains the relevance of each match. Therefore, we use a winner based paired comparison (WPC) method [7].

We use Human Vision Component B5T-007001 (OMRON, Japan) to acquire gaze information which includes the viewing position and the number of times users looked. We judged the viewing position from the position and angle of the face as well as the angle of gaze.

2.2 Evaluation Method of the Solution Candidate

The proposed system gives one point to the individual that is being observed when gaze information is acquired. The system repeatedly acquires gaze information over a fixed duration. Finally, the system determines the winner from the score.

Next, the system evaluates each individual with a value using the wins and losses. Figure 2 shows the evaluation process for each individual. In advance, the system allocates one point to all individuals generated in the same generation. The system determines the outcome of a match based on the users' gaze information and adds the loser's evaluation value to the winner's. In Fig. 2, first, the system gives each generated individual the one point. Then, A beats B in the first round. Therefore, the system adds the evaluation value of B to the evaluation value of A. The evaluation value of A is then 2 points. If A beats C in the second round, the system adds the evaluation value of C to the evaluation value of A so that it is now 3 points. Assuming D beats A in the third round, the system then adds the evaluation value of A to the evaluation value of D. The evaluation value score of D is hence 4 points. The final evaluation value of A is 3 points, B is 1 point, C is 1 point, and D is 4 points.

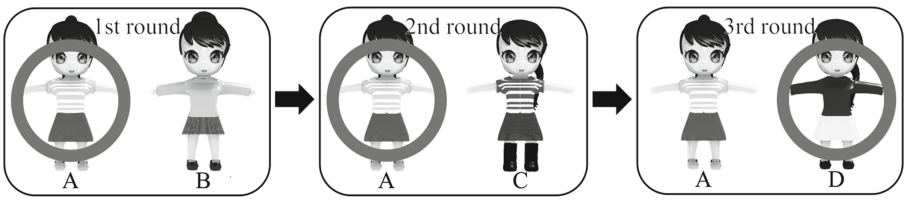

Fig. 2. The evaluation process for each individual

2.3 Evaluation Interface

Figure 3 shows the evaluation interface of the proposed system. The user sits in front of the screen and inputs their port number and the baudrate using the keyboard. Next, when the user presses the START button, the system presents two

Fig. 3. Evaluation interface of the system

different women's clothing coordination on the screen. The user looks at his/her preferred clothing coordination of the two options presented. After the clothing coordination is presented for 5 s, the system evaluates each individual from the obtained gaze information. The system presents the clothing coordinates of the next competition based on the evaluation value of the current one. The user continues this operation for five generations. After the final generation is evaluated, the system presents the clothing coordination of the highest evaluation value.

2.4 Coordination Parts

Figure 4 the genetic coding of the clothing coordination. The clothing coordination consists of four parts: hair, tops, bottoms, and shoes [7]. Each part has eight or sixteen designs, which are expressed using 3 or 4 bits. The system can then create 16,384 designs because the gene length is 14 bits.

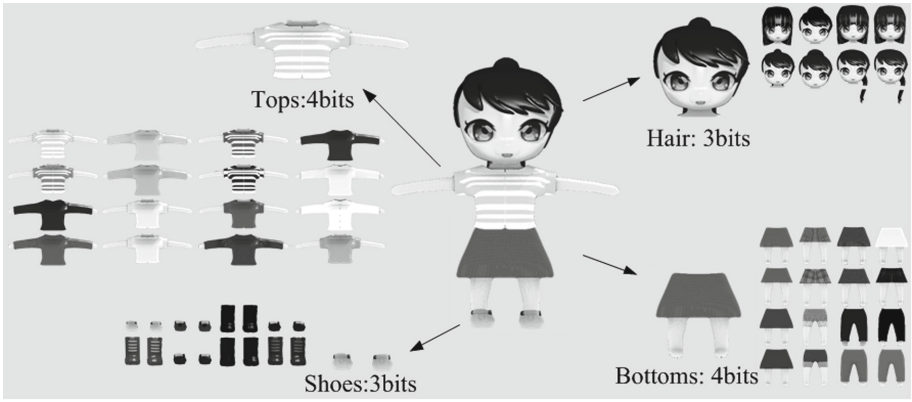

Fig. 4. The genetic coding of the clothing coordination

3 Evaluation

3.1 Experiment Summary

We conducted two verifications using the proposed system. The first verified the effectiveness of using gaze information in the evaluation of IEC for reducing the user load. The second was to evaluate the effectiveness of using gaze information for IEC evaluation that includes multiple users. In this research, we used a system that evaluates with gaze information and a system that performs manual evaluations. In this experiment, we compared the performances of the proposed and conventional systems.

Table 1 shows the parameters in this experiment. When solutions begin to converge, the system generates similar clothing coordination. In such a case, users will become bored and feel a psychological load. Hence, we set the mutation rate to as high as 20%. The proposed system sets the display time to 5 s because the user sees the entire clothing coordination being displayed.

We conducted the following two experiments.

1. A comparison of the user load and satisfaction with the generated clothing coordination in the proposed system versus a conventional system.
2. An investigation of the satisfaction level with the generated clothing coordination when multiple users are targeted.

In Exp.1, 23 university students in their twenties participated. We used two systems: the proposed system and a conventional system. First, each subject used both systems. We randomly determined which system the subject used first. After that, subjects evaluate the satisfaction level of finally generated coordination and the evaluation load in 5 stages evaluation.

Exp.2 consisted of 10 pairs of subjects' consisting of university students in their twenties. We used the proposed system. First, each subject pair used the proposed system together. After that, subjects evaluate the satisfaction level of finally generated coordination in 5 stages evaluation.

Table 1. Parameters in the experiment

Population	8
Gene length	14 bits
Generations	5
Selection method	Roulette selection + Elite preservation
Crossover method	Uniform crossover
Mutation rate	20%
Display time (the proposed system only)	5 s

3.2 Experimental Results

Figure 5 shows the satisfaction results for the final generated clothing coordination in Exp.1. In both systems, the average satisfaction with the generated clothing coordination was about 3.9. To confirm the statistical significance of this result, we performed a sign test but did not confirm a significant difference at a significance level of 5%. Therefore, we conclude that it is possible to generate a satisfactory design to some extent by using gaze information as a method of IEC evaluation.

Figure 6 shows the evaluation loads of the proposed system in Exp.1. The evaluation load average of the proposed system was 1.9, and the evaluation load average of the conventional system was 1.8. To confirm the statistical significance of this result, we performed a sign test but did not confirm a significant difference at a significance level of 5%. Therefore, it seems that there is almost no difference in the evaluation burden of the proposed and conventional systems.

Figure 7 shows the result of satisfaction of with the finally generated coordination in Exp.2. The average satisfaction of the final generated clothing coordination was about 3.75. Although there are some differences in the satisfaction levels of the two users in a pair, it is considered that system can create a clothing

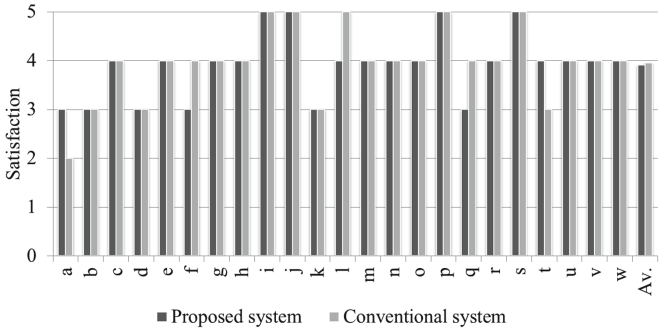

Fig. 5. Satisfaction of the generated coordination

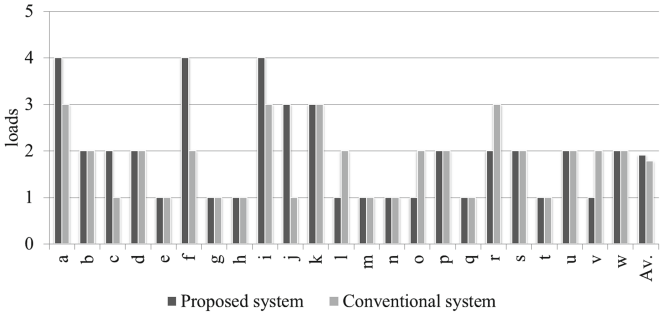

Fig. 6. Evaluation loads of the system

coordination that satisfies the users. Therefore, we confirm that it is possible to generate a satisfactory design to some extent even if the gaze information of two users is used for IEC.

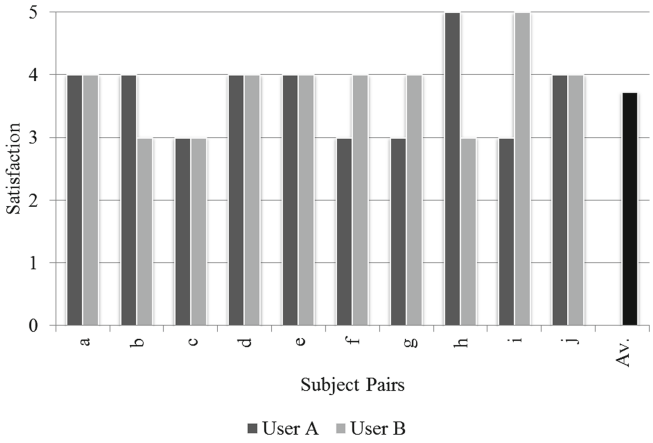

Fig. 7. Satisfaction of the generated coordination

4 Conclusions

We proposed an IEC system employing users gaze information. We verified its effectiveness on real users by using the proposed system. In the experimental results, we confirmed that the proposed system is effective for reducing the user evaluation load. In addition, we confirmed that it is effective to use gaze information in the evaluation of IEC even in the case of multiple people. In future work, we will further verify its effectiveness and consider practical application systems.

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