



Development of an Interactive Evolutionary Computation Catalog Interface with User Gaze Information

Hiroshi Takenouchi¹(✉) and Masataka Tokumaru²

¹ Fukuoka Institute of Technology, Fukuoka 811-0295, Japan
h-takenouchi@fit.ac.jp

² Kansai University, Osaka 564-8680, Japan

Abstract. We propose a catalog interface for the Interactive Evolutionary Computation (IEC) system. When a user views a product catalog, the system obtains the user's gaze information and implements evolutionary computation. We verify the effectiveness of the proposed system using evaluation experiments with real users. The experimental results show that the proposed system can generate solutions that offer results equivalent to comparable systems and reduce the evaluation load of the users.

Keywords: Gaze information
Interactive Evolutionary Computation · Catalog interface

1 Introduction

Internet users often purchase products from online product catalog. Users search for their favorite products with keyword retrieval or product feature searches. However, they must input information related their preferences and may not always search for their favorite products.

In this study, we built a system with an Interactive Evolutionary Computation (IEC) method using a user's gaze information to generate or recommend a product that satisfies the user. This method creates products based on the user's subjective evaluations and the Evolutionary Computation (EC) technique [1]. Previously proposed systems that have applied IEC include various image retrieval [2] and music generation [3] systems. However, in such systems, the user evaluation loads of candidate solutions are large.

To address this problem, IEC researchers have proposed a system with biometric information using methods that utilize a user's biometric information, such as heartbeats or brainwaves to evaluate products [4, 5]. The system can obtain a user's evaluation information as the user is viewing the candidate solutions. User evaluation is achieved without the system evaluating the candidate solutions expressly. However, the user must wear special devices such as a heart rate meter or an electroencephalograph, for the system to monitor biometric information. Such IEC systems have been difficult to popularize.

To provide an alternative systems, we applied user gaze information to the evaluation of products. Such information includes the potential preferences of the users [6]. To apply a user's gaze information to the evaluation of candidate solutions, IEC systems can obtain the user's evaluation information by merely having the user view multiple candidate solutions. Such a technique is effective for marketing applications that require a good understanding of a user's potential preferences. Moreover, when a user views a product catalog, the system learns the user's preferences and recommends various goods that are likely to satisfy the user.

Previous IEC systems using user gaze information have been proposed [7, 8]. Although, while their results achieved a certain level of effectiveness, such studies have failed to clearly verify the overall effectiveness of a user gaze information-based method. Moreover, user motivation is thought to be an issue in the evaluation of the objects used in these systems. In a previous study, we verified the effectiveness of one method in terms of the evolutionary performance of candidate solutions but using a conventional IEC system that utilized a 10-stage evaluation method as a comparison method [9]. However, our study performed only a basic investigation and did not build a system to be applied in real situations.

Hence, we propose an IEC system that applies catalog-type interfaces and evaluates product designs using user gaze information. The user views product designs with the catalog interface and turns pages to view other products. The proposed system performs EC operations while the user turns the pages. Moreover, the proposed system uses the Genetic Algorithm (GA) method as an EC method in the IEC. According to the user's gaze information, product designs that fit the user's preferences are displayed on the right-hand pages of the catalog, and various recommended product designs are displayed on the left-hand pages.

We perform the evaluation experiment with real users to verify the effectiveness of the proposed system with regard to the performance of its EC of candidate solutions and the degree of usability of the system. The experiment uses three systems. The first system is the proposed system, and the second one is the manual evaluation system, in which users evaluate candidate solutions using a 5-stage evaluation method. The manual system had the same interfaces as the proposed one. The last system is our previous system [9]. After the experiment, we distribute questionnaires to users in order to investigate the satisfaction level of generated designs as well as the user's evaluation load and the appearance of the interfaces.

2 Proposed System

2.1 Schematic of the Proposed System

Figure 1 shows the schematic of the proposed system. A user creates a design of their favorite running shoes. First, the system generates the initial gene-type candidate solutions, which consist of bit patterns. Next, the system presents

the product designs corresponding to the gene-type candidate solutions. Then, the user views all candidate solutions as if viewing a product catalog while the system measures the user's gaze information. The user turns the pages to view other products. As the user views some of the products, the proposed system evaluates candidate solutions with the user's gaze information and creates new candidate solutions by GA processing.

Each candidate solution is evaluated using the user's gaze information. To obtain the user gaze information, we use a Tobii Pro X2-30 eye tracker, which measured the user's gaze information at a rate of 30 [Hz].

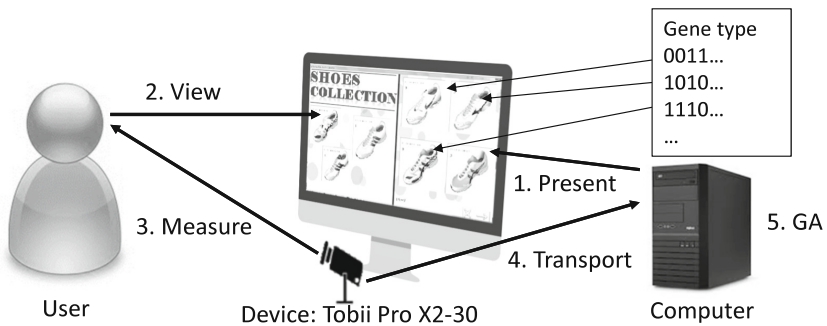


Fig. 1. Outline of the proposed system

2.2 Evaluation Interface

Generally, a product catalog has various layout interfaces for presenting the various product designs. Therefore, the proposed system changes the interface at every generation.

Figure 2 shows the interfaces of the proposed system. After the system has started, it presents initial candidate solutions on the interface (Fig. 2(a)). The user views the presented designs freely. If the user clicks the allow button (bottom right of the interface) to turn the pages, the system randomly chooses from the interfaces (Fig. 2(b)–(c)) and presents the new designs. The interfaces include seven to eight designs. The proposed system generates eight candidate solutions for every generation. If the proposed system uses an interface that has only seven presented designs, the design that is not presented is assigned an evaluation value of 0.

2.3 Evaluation of Candidate Solutions

Figure 3 shows the candidate evaluation of the proposed system. First, the proposed system measures the user gaze positions for each sampling (black circles in Fig. 3) and then counts the number of user gaze positions for each candidate solution. If the gaze position is away from the interface, the system does not

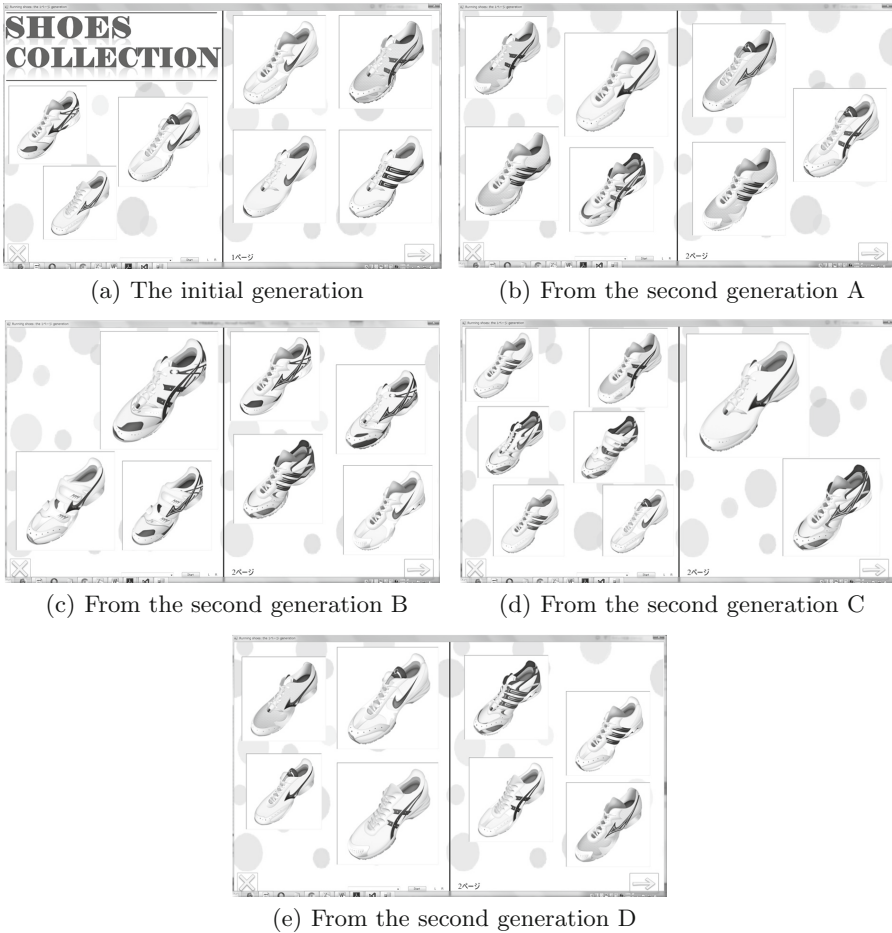


Fig. 2. Evaluation interfaces of the proposed system

measure or count the number of user gaze positions. For example, when the number of user gaze position samples of each candidate solution p_1-p_8 is s_1-s_8 , each s_i equals 3, 2, 2, 1, 3, 3, 2, and 2. Next, the proposed system normalizes these values in a range from 0 to 100. Then, the evaluation values of each candidate solution v_i are 100, 50, 50, 0, 100, 100, 50, and 50. The system uses these evaluation values v_i for GA processing.

3 Evaluation Experiments

3.1 Outline of the Experiment

Here, we investigate the effectiveness of the proposed system with real users. Twenty subjects (ten men and ten women) in their twenties participate in the

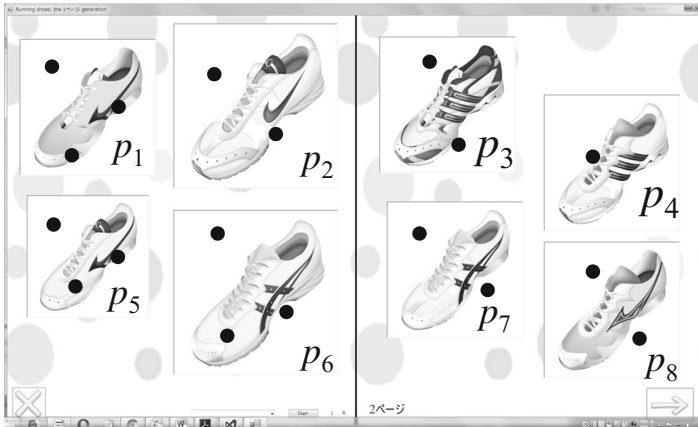


Fig. 3. Evaluation method of candidate solutions of the proposed system

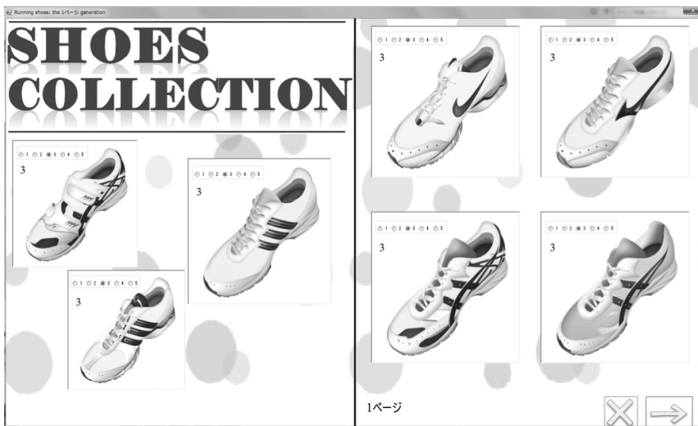


Fig. 4. Interface of the manual evaluation system

experiment, which uses three systems: the proposed system, the manual evaluation system, and our previous system.

Figure 4 shows the interface of the manual evaluation system. The subject inputs the evaluation values using radio buttons beside each design. These evaluation values are normalized within a range of 0–100 for GA processing. Whenever the user turns the pages, the system changes the interface and presents new designs as well as the proposed system. The candidate solutions of our previous system are evaluated the same manner as is the proposed system.

Table 1 shows the experimental parameters. All the systems uses the same experimental parameters. We use running shoes designs [9]. Each design consists of five parts. Each part has eight designs expressed by 3 bits (gene length: 15 bits). The system can generate 32,768 running shoe designs. The subjects used

Table 1. Experimental parameters

Gene row	Bit pattern
Gene length	15 bits
Generations	10
Candidate solutions	7 or 8
Selection	Roulette selection + elite preservation
Crossover	Uniform crossover
Mutation rate	20%

each system to view freely, evaluate, and select designs for shoes that they would want to wear for running.

We distribute questionnaires to survey the satisfaction levels of the generated candidate solutions as well as the usability (i.e., the level of evaluation load) and appearance of the interface of each system. We also measured the time taken by the users to evaluate the designs. Moreover, we considered the effect of the order in which each system was used and randomly set the order for each subject.

3.2 Experimental Results

Figure 5 shows the satisfaction level for the generated designs and degrees of usability. The average satisfaction level for all the systems was more than 3.5. We performed the statistical test to confirm whether there were statistically significant differences in the satisfaction levels of each system. However, we made no confirmations when the significance level was 5%. We demonstrated that the proposed system could create designs that satisfied the subjects.

The average usability of the proposed and previous systems was more than 3.5, and that of the manual evaluation system was about 2.7. With the results of the statistical test at a 5% of significance level, we confirmed statistically significant differences between the proposed and manual evaluation systems as well as between the previous and the manual evaluation systems. When using the manual evaluation system, the subjects manually evaluated the designs. However, in the proposed and previous systems, they evaluated the designs more easily, because they only viewed the designs. The operation loads of the proposed and previous systems were smaller than that of the manual evaluation system.

In an IEC system, the time spent evaluating designs is a significant factor in reducing the evaluation loads of users. Figure 6 shows the time spent evaluating the designs for each system. The subjects used ten generations with each system. The evaluation time was measured from the point of the initial presentation of the designs to the completion of the evaluations in the final generation. The evaluation times required for all systems were less than 240 [s]. The evaluation times required for the proposed and previous systems were shorter than that for the manual one. With the results of the statistical test with the 5% of the significance level, we confirmed significant differences among all the systems.

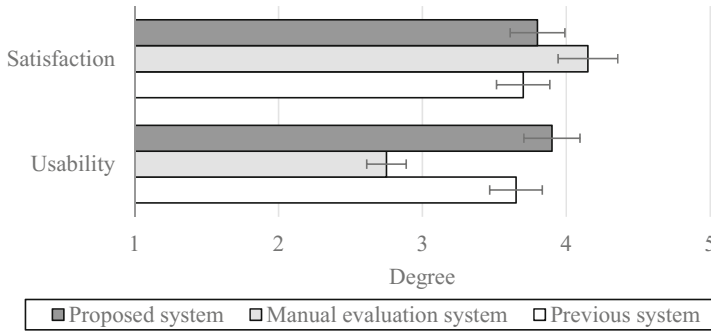


Fig. 5. Satisfaction level for the generated designs and usability degree

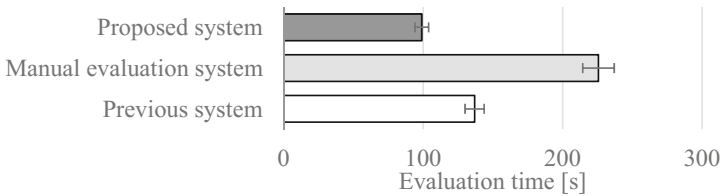


Fig. 6. Evaluation time for the proposed system

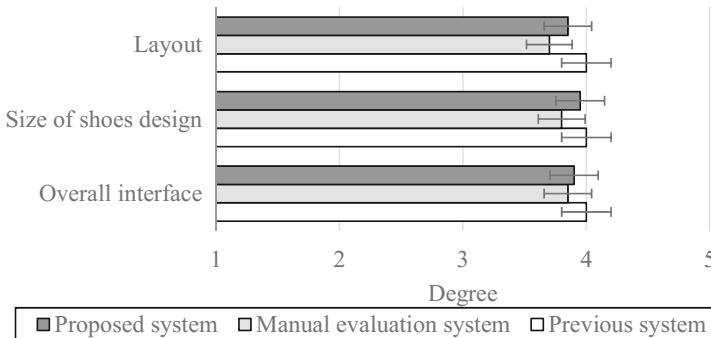


Fig. 7. Appearance of the interfaces

These differences were due to the subjects having only viewed the presented designs or their favorite ones using the proposed and previous systems.

Figure 7 shows the results of the questionnaires given to the users for evaluating the interfaces of the proposed system. We assumed the use of the proposed system in real situations, as the appearance of the interface was important for this system. The average of all the questionnaire items was the same. Therefore, we did not confirm the advantage of the appearances of the interface of the proposed system. Some subjects made the following comments:

- It is interesting that the proposed system has various interfaces.
- The previous system was easier to view than the proposed system because the former arranged the designs in a row.

We intend to improve the proposed system in light of these comments.

4 Conclusions

We proposed an IEC catalog interface system using a user's gaze information to generate the user's favorite product automatically. We evaluated the usability of the proposed system by conducting an experiment with real users. In the future, we will improve the evolutionary algorithm to make more effective searches for a user's favorite products.

References

1. Takagi, H.: Interactive evolutionary computation: fusion of the capabilities of EC optimization and human evaluation. *Proc. IEEE* **89**(9), 1275–1296 (2001)
2. Lai, C.C., Chen, Y.C.: A user-oriented image retrieval system based on interactive genetic algorithm. *IEEE Trans. Instrum. Meas.* **60**(10), 3318–3325 (2011)
3. Marques, V.M., Reis, C., Machado, J.A.T.: Interactive evolutionary computation in music. In: 2010 IEEE International Conference on Systems Man and Cybernetics, SMC, pp. 3501–3507 (2010)
4. Unehara, M., Yamada, K., Shimada, T.: Subjective evaluation of music with brain wave analysis for interactive music composition by IEC. In: Joint 7th International Conference on Soft Computing and Intelligent Systems and 15th International Symposium on Advanced Intelligent Systems, SCIS&ISIS 2014, pp. 66–70 (2014)
5. Fukumoto, M., Nakashima, S., Ogawa, S., Imai, J.: An extended interactive evolutionary computation using heart rate variability as fitness value for composing music chord progression. *J. Adv. Comput. Intell. Intell. Inf.* **15**(9), 1329–1336 (2011)
6. Moniri, M.M., Valcarcel, F.A.E., Merkel, D., Sonntag, D.: Human gaze and focus-of-attention in dual reality human-robot collaboration. In: 12th International Conference on Intelligent Environments, pp. 238–241 (2016)
7. Pallez, D., Collard, P., Baccino, T., Dumercy, L.: Eye-tracking evolutionary algorithm to minimize user's fatigue in IEC applied to interactive one-max problem. In: Proceedings of the 10th Annual Conference on Genetic and Evolutionary Computation, GECCO 2007, pp. 2883–2886 (2007)
8. Holmes, T., Zanker, J.: Eye on the prize: using overt visual attention to drive fitness for interactive evolutionary computation. In: Proceedings of the 10th Annual Conference on Genetic and Evolutionary Computation, GECCO 2008, pp. 1531–1538 (2008)
9. Takenouchi, H., Tokumaru, M.: Applying gaze information to interactive evolutionary computation. In: The 33rd Fuzzy System Symposium, TF1-3, pp. 357–360 (2017). (in Japanese)