GAZE-VOTING INTERFACE FOR INTERACTIVE EVOLUTIONARY COMPUTATION CONSIDERING THE KANSEI EVALUATION OF MULTIPLE PEOPLE

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ABSTRACT

The aim is to develop an Interactive Evolutionary Computation (IEC) system that can automatically generate designs or media content based on the preferences of multiple users by capturing their gaze movements and by using this as a solution to evaluation. In the beginning, experiments conducted have revealed that stimulated images to subjects managed to catch the movements of their gaze. Consequently, it is found that the images with the longest look and the greatest preference by the subjects occurred at a rate of approximately 63%. This suggests that the subjects choose their favourite images. Furthermore, the IEC's algorithmic performance is simulated based on the results from the experiment. Consequently, it is verified that solutions using the IEC algorithm have partly evolved with a voting accuracy of 63%. From these observations, it is expected that the IEC system is built to catch the movements of the users' gaze and the evolution in solutions are preferred by multiple users by making users more conscious in advance.

Keywords: *multiple user preferences, interactive evolutionary computation, gaze movements*

1. INTRODUCTION

1.1. IEC Overview

The IEC method is able to assist in creating designs or media content that is based on the user preferences through the interaction between a user and a computer [2]. Several studies have examined the improvement in various application systems or interfaces [3-6]. The genetic algorithm (GAs) or Tabu Search is used as the basic technology of the IEC. Therefore, by replacing the fitness function with a user's evaluation in an IEC algorithm, the IEC can be used to

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reflect the intuitive preferences of the user to optimise the design or content. Systems using the IEC have been studied to create, for instance a pose generation system preferred by users [3] or an interior design support system [4]. The IEC system reflected the Kansei of multiple users have been studied. These include the IEC systems for fashion coordination preferred by multiple people [5] or a system that generates solutions to form a consensus among all the participants of a conference [6].

Sakai et al. developed an IEC system for multiple people by using an algorithm that accepts multiple user evaluations [5]. The system is able to obtain sufficient number of evaluations through an interface using voting buttons and digital signage to generate fashion coordination that satisfies the preferences of multiple users. It is possible to generate better solutions based on users' preferences in these multiplayer IEC systems by using evolutionary calculation.

1.2. The Interface of IEC in Consideration of the Kansei Evaluation of Multiple People and its Limitations

In an IEC system that considers the Kansei evaluation of multiple people, it is crucial to create an interface of such that each user is able to vote easily. In a conventional IEC system, for instance, users select solution candidates by pressing buttons [5]. Users need to operate the system one at a time when they vote. This method may act as an obstacle for obtaining a large number of votes in a short period of time.

Therefore, instead of utilising the conventional voting method, we consider using a user's gaze information directly as a solution for evaluation. For instance, if a user's preference can be estimated from a casual gaze movement of the user who passed in front of the system, the IEC interface can be expected to collect votes easily. In order to use the gaze information as a voting interface, it is necessary to investigate the features of the gaze movement. In addition to that, the preferences estimated from the gaze information are considered to partially contain an error compared to the conventional solution evaluation methods, which actively selects the solution candidates. Therefore, it is necessary to verify the extent of evolutionary performance that is maintained as IEC algorithm with solution evaluation including errors.

2. PREVIOUS STUDIES AND THEIR LIMITATIONS

Several previous studies have dealt with the relationship between the gaze movements and the user preferences. Shimojo et al. [7] showed a pair of facial images to subjects. The subjects were instructed to decide which image is more attractive. Simultaneously, the subject's gaze movements were analysed. Consequently, a subject's gaze was initially distributed evenly between the two stimuli, which gradually shifted towards the face that the subject eventually chose.

Several studies have reported that human gaze movements have been affected by preferences or by a stimulation that was generated by images. However, in previous studies, subjects recognised that their gazes were being analysed as part of the experiment. In this study, the aim is to estimate user's preference from a user's casual, unconscious gaze movements so that a simple IEC interface is created. Therefore, experiments that conceal the fact that gaze information is conducted and analysed, allowing the subjects to act naturally during the experiment. In addition to that, the gaze movements after the subjects have chosen their preferred images are re-analysed.

3. EXPERIMENT ON THE RELATIONSHIP BETWEEN THE GAZE MOVEMENTS AND THE USER PREFERENCES

3.1. Outline of the Experiment

A number of stimulus images and are prepared and showed to the subjects. The subjects chose the images based on their preference. At the same time, the gaze movements of the subjects before and after they chose the images were analysed. After the subjects chose their preferred images, the subjects were asked to reveal which images that has been chosen.

The method of digital signage to present the stimulus images was adopted. This methodology has a feature that contents can be displayed to a large group. The "HVC-P" that was developed by the OMRON Corporation was adopted as a tool to analyse the gaze movements. The HVC-P is an image-sensing component equipped with a camera that integrates 10 types of image analysis functions, including facial detection and gaze estimation [9]. The photograph of the experimental environment is shown in Fig. 1.

In this experiment, two digital signage were set up side by side in the same direction, and the HVC-P was positioned at the centre of these digital signage for it to be hidden from the subjects. Then, the stimulus images in the digital signage were displayed. These images were presented to the subjects at approximately 1.5 m from the digital signage. The gaze movements of the subjects using HVC-P were analysed and recorded. Considering the analytical accuracy of HVC-P, two distinct modes of stimulus image presentation were employed. As shown in Fig. 2,

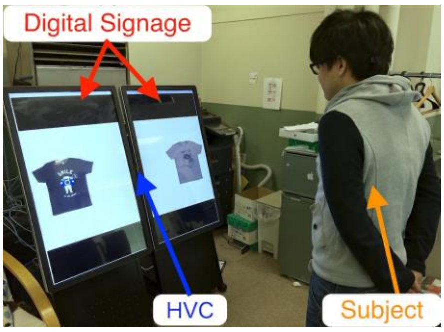

Figure 1: A photograph of the experimental setup (a two-stimulus image presentation)

the first is a two-stimulus image presentation, which displays one stimulus image on each digital signage. The second is a four-stimulus image presentation, which displays two stimulus images on each digital signage.

In addition, the subjects were encouraged to not only vaguely look at the stimulus images but were also asked to possess a kind of intention, designated by the experimenter. In general cognitive psychology, it is believed that human gaze movements are affected by their consciousness (i.e., psychological state). Therefore, it is believed that the psychological condition of a subject influences his or her gazing time for the stimulus. Accordingly, in this experiment, subjects are encouraged to have two types of consciousness and present stimulus images: 1) neutral consciousness (thinking nothing) and 2) thinking about what I prefer and choose.

Several T-shirt images are used as the stimulus images. A T-shirt is suitable for this experiment because it is an object for which a subject can decide his or her preference in a short period of time. The T-shirt image that was chosen is the "Design T-shirts Store graniph" [10]. The stimulus images used in this experiment are shown in Fig. 2.

3.2. Experimental Method

First, it is encouraged that the subjects to be in the "neutral consciousness” state and started analysing the gaze movements using the HVC-P. The experiment was performed in the following manner:

1. Presentation of stimulus images: Several sets of T-shirt images at regular intervals were consecutively presented.

In the case of the two-stimulus image presentation, 15 pairs of stimulus images were displayed for every 5 seconds. In the case of the four-stimulus image presentation, 10 sets of stimulus images were displayed every 8 seconds. At this time, all subjects just looked at the stimulus images and made no selections.

Next, the subjects were asked to choose an image from all stimulus images.

Figure 2: Presentation formats of stimulus images

2. Re-presentation of stimulus images: All sets of stimulus images that were presented in step (1) were re-presented. The order of presentation was shuffled.
3. Determining which images the subjects chose: The subjects chose their preferred image out of all the presented images.

There is no time limit set for subjects, and all subjects told us verbally when they chose their preferences. The chosen images and the response times for all of the subjects. After the subjects made their choices, the same stimulus images were presented continuously for 10 seconds. Steps (2) and (3) were repeated for all stimulus images.

3.3. Experimental Results

The focus is the duration of the gazing time for the stimulus images and on the comparison of the images that had longer gazing times with the images that were chosen by the subjects.

A total of 39 men and women aged 20-22 years have participated in the study. The two-stimulus image presentation was presented to 20 subjects, and the four-stimulus image presentation was presented to 19 subjects. The average time for all subjects from the time of presentation of images to the time of choice made by the subjects was 2.40 seconds for the two-stimulus image presentation and 4.18 seconds for the four-stimulus image presentation.

The experimental results for the two-stimulus image presentation are shown in Figs. 3-5. Each graph shows the number of accorded cases and non-accorded cases consisting of images that was gazed the longest and the images preferred by subjects. Each subject was shown 15 stimulus images, so the total number of cases were 15. Fig. 3 shows the results for the subjects with neutral consciousness, whereas Figs. 4 and 5 show the results for the subjects that were thinking about the preferences (Fig. 4 shows the results for the subjects before making a choice, whereas Fig. 5 shows the results for the subjects after making a choice). The subject's preferences were notable in accordance with the gazing time shown in Fig. 4. The average of the accorded rate (accorded cases per all cases) was 63.5%, indicating that the accuracy of estimating the preference from the gazing time is approximately 63%. On the other hand, even in the case of the four-stimulus image presentation, subjects tend to gaze at their preferred images for a long time; however, the average of the accorded percentages was only approximately 36%.

While there are large subject-to-subject variations in the ratio of the accorded cases to non-accorded cases for subjects with neutral consciousness (Fig. 3), there was no significant difference between the accorded side and the non-accorded side at the 1% level according to the Wilcoxon rank sum test ($p = 0.61$). This is in a sharp contrast to the differences apparent in Fig. 4 ($p = 0.0000023$) and Fig. 5 ($p = 0.000065$), where the number of accorded cases significantly exceeded the number of non-accorded cases recorded either before or after the choices had been made.

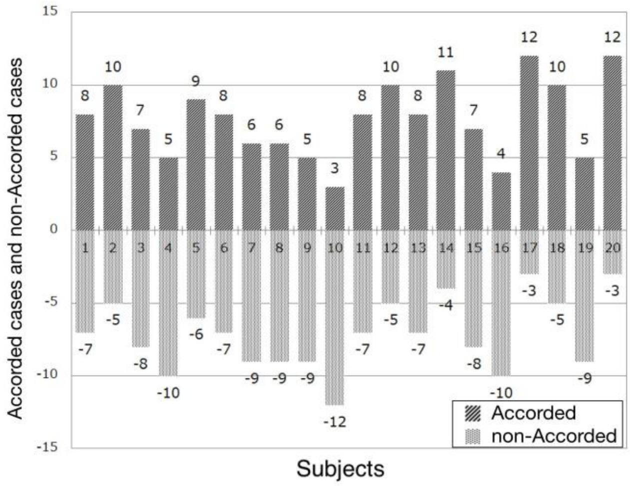

Figure 3: Results for the subjects with neutral consciousness

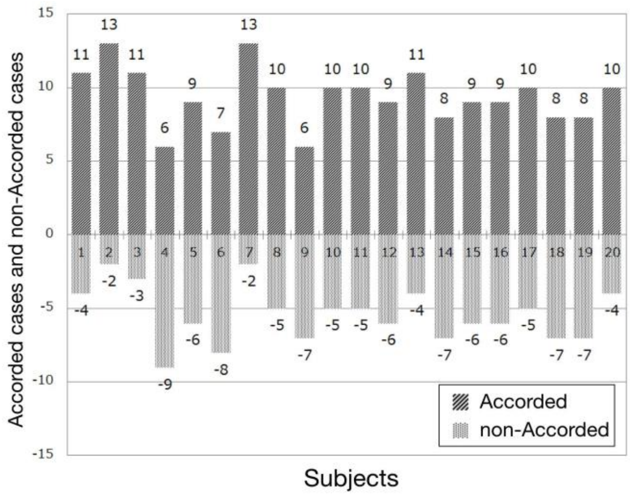

Figure 4: Results for the subjects before making a choice

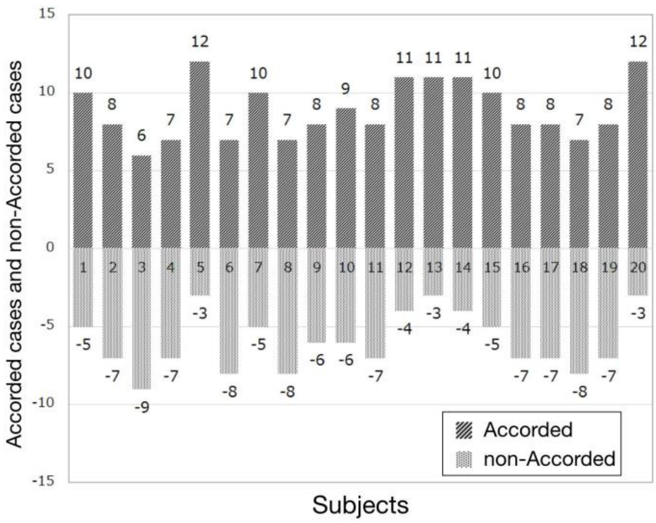

Figure 5: Results for the subjects after making a choice

3.4. Consideration

The results showed that the subjects in the neutral consciousness state do not express their preferences through gazing time. Thus, it is difficult to estimate the user preferences by using the gazing duration time from this state. However, if the subjects are encouraged to focus on the second type of consciousness, i.e., "thinking about what I prefer and choose," they tend to closely gaze at the image they like for a longer period of time in the two-stimulus image presentation. In contrast, in the four-stimulus image presentation, it is observed that there is a tendency among the subjects to gaze at their second most favourite image or at a disliked image throughout the experiment.

4. SIMULATION OF THE EVOLUTION PERFORMANCE

4.1. Simulation Method

In this simulation, the Paired Comparison Voting (PCV) method was adopted, which is an IEC algorithm that reflects the preferences of multiple people [5]. The PCV method provides only a two solution candidate to the user. Therefore, the estimated preferences from the users' gaze information can be used as a solution evaluation in the PCV method. The PCV method determines a superior solution out of two-candidates from the votes of multiple users, and it generates new solutions through the evolution calculation for each competition. Fig. 6 shows an outline of the PCV system using the example of T-shirt design. Each user chooses his or her favourite image from two solution candidates. When a plurality of users participates in voting and a certain number of votes gather, the PCV operations create a uniform crossover of the GA to two solution candidates. The PCV method creates masks according to the voting ratio for each solution candidate, generates two new solutions, and accepts the votes of the users again.

In this simulation, the evaluation agents comprising bit strings were used instead of real users. Each evaluation agent has its own favourite bit strings of solutions. They compared their own bit strings with the presented bit strings and evaluated the solution candidates. From the 1,000 generated evaluation agents, some evaluation agents that were selected randomly participated and voted for a paired comparison. Each individual solution has 30 bits of gene length. In total, 16 solution candidates were generated for each generation and child individuals were generated by using uniform crossover according to the voting ratio.

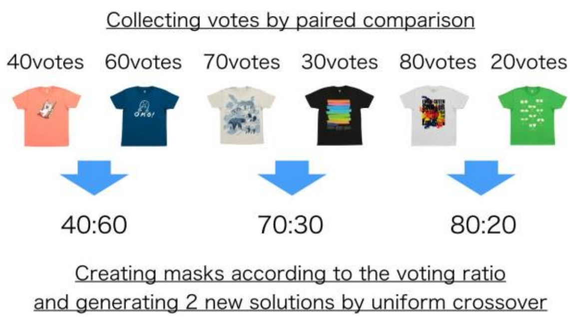

Figure 6: Outline of the paired comparison voting (PCV) method

The generation parameter was set to 1,000 to ensure that there were adequate generations to evolve sufficiently. After the pre-simulation operation, the mutation is set and rated to 1% in order to optimise the performance of the PCV method. The bits were randomly selected in the mutation rate process based on the mutation rate from all solution bits and inverted. In order to eliminate the probabilistic influence, the simulation was repeated for 100 times.

In this simulation, the evaluation agents are comprised of parameters such as the probability of voting incorrectly. Based on our experimental results, the average of the accorded rate was approximately 63%; however, there were variations from subject to subject. Fig. 7 shows the distribution of subjects in every accorded rate. From this data, the standard deviation was calculated to be 12.4357. Thus, it is assumed that the distribution of these subjects revealed a normal distribution with an average of 63.4745 and a standard deviation of 12.4357. In this simulation, all the evaluation agents comprised a value of voting accuracy that was consistent with this probability distribution.

Furthermore, every evaluation agent has a preference trend that is associated closely with collectiveness. In general, the preferences for design varies between users. However, it is unlikely that a user would have a preference that is different from those of all other users. First, an evaluation agent with random bits as a centre of preference is created. Then, a group of evaluation agents by inverting the bits of the centre of the preferred evaluation agent in the range of 6 bits or less is created.

4.2. Result and Discussion of Simulation

Fig. 8 shows the transition of the average evaluation value for each generation. It shows up to 200 generations, where the increase in the average evaluation value had stopped at any case. In this case, the average evaluation value is the average of the matching degree of each bit of all evaluation agents and the elite solution candidate in each generation.

The higher the average evaluation value becomes, the more the users prefer the solution candidate. In addition to the accorded rate obtained from the result of the experiment, several rates between 100% and 52% for comparison are set.

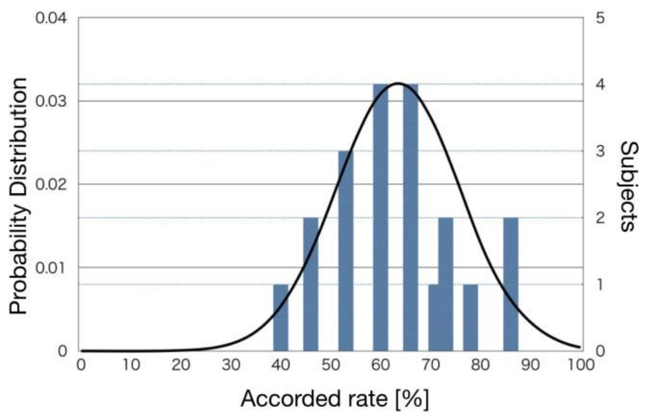

Figure 7: Distribution of subjects and probability distribution curve

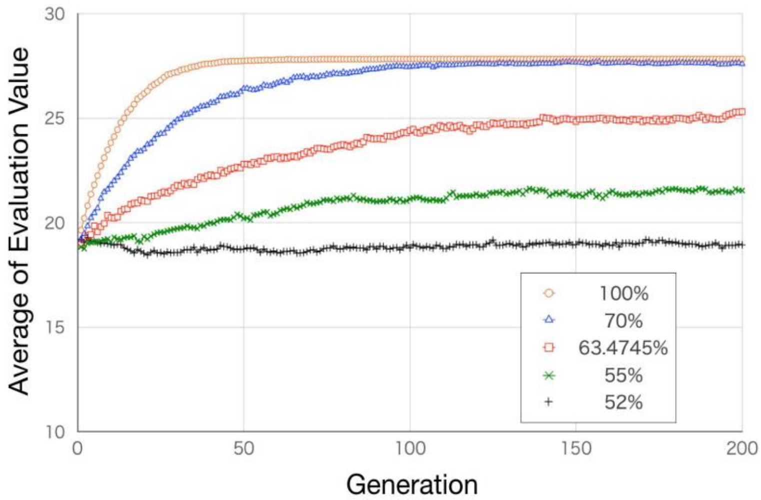

Figure 8: Transition of the average evaluation values

At a 100% accorded rate, the evaluation agents always vote for their favourite solution candidates. This reveals the performance of the original PCV method. When the accorded rate dropped to 70%, although the rise at the initial generation becomes slow, finally, the same performances as the rate of 100% were obtained. At an accorded rate of 63.4754%, the result of our experiment, the transition did not reach a performance that is similar to as that achieved at 100% accorded rate. However, the average evaluation value is increased to some extent. On the other hand, when the accorded rate dropped to 52%, the average evaluation value was nearly flat and the solution did not evolve in the desired direction.

5. CONCLUSION

The primary aim is to develop an IEC system that can automatically help in creating designs or media contents based on the user preferences by using their gaze information as a solution for evaluation. In achieving this, an experiment on the relationship between the gaze movements and the user preferences in order to verify the means to estimate the preference from the gaze information was conducted. Then, to verify the solution evolution performance of the IEC algorithm, an evolution simulation based on the experimental results was performed.

In this experiment, it is found that the images that received the longest gaze and the images preferred by the subjects were accorded at a rate of approximately 63%. As indicated in a previous study, gazing time of the subjects increased for their favourite images. The participants who did not recognized that their gazes were being analysed also had the same reaction.

In the evolution performance simulation, a simulation to verify the evolution performance of the solution using the PCV method was conducted which is an IEC algorithm that considers the Kansei evaluation of multiple users. The simulation results showed that a performance as good as that of the original algorithm could not be obtained. However, the solution evolved towards the preference of each evaluation agent when the generations progressed.

From the above results, considering the Kansei evaluation of multiple people, it is expected to develop a gaze-voting IEC system by asking the participants to be more conscious in advance. It is assumed that this system will be operated in facilities or on the street with many people. As a way to increase consciousness among the users who are walking on the streets, a list of instructions will be displayed beside the IEC system so that users unconsciously think about their preferences. Currently, an IEC system for real multiple users is planned to be developed.

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OMRON Sensing egg project, https://plus-sensing.omron.co.jp/egg- project/

Design tshirts store graniph, http://www.graniph.com