Evolutionary Programming based Recommendation System for Online Shopping

Jehan Jung*, Yuka Matsuba†, Rammohan Mallipeddi*, Hiroyuki Funaya†, Kazushi Ikeda† and Minho Lee*,**
*Dept. of Sensor Engineering, **School of Electronics Engineering, Kyungpook National University, Taegu, South Korea.
E-mail: {crossjjh, mallipeddi, mholee}@knu.ac.kr.
†Graduate School of Information Science, Nara Institute of Science and Technology, Nara, Japan.
E-mail: {yuka-m, hiroyuki-fn, kazushi}@is.naist.jp

***Abstract*— In this paper, we propose an interactive evolutionary programming based recommendation system for online shopping that estimates the human preference based on eye movement analysis. Given a set of images of different clothes, the eye movement patterns of the human subjects while looking at the clothes they like differ from clothes they do not like. Therefore, in the proposed system, human preference is measured from the way the human subjects look at the images of different clothes. In other words, the human preference can be measured by using the fixation count and the fixation length using an eye tracking system. Based on the level of human preference, the evolutionary programming suggests new clothes that close the human preference by operations such as selection and mutation. The proposed recommendation is tested with several human subjects and the experimental results are demonstrated.**

I. Introduction

Online shopping is a form of electronic commerce that allows consumers to buy goods or services over the internet. Recently, online shopping is emerging as a new marketing channel, and thus understanding the need and expectations of the customers are considered a prerequisite for activating the consumer-oriented electronic commerce market. Online shopping differs from the traditional retail formats in many ways. A unique characteristic of online shopping is that consumers cannot touch or smell the products, as they usually do in the traditional retail outlets, and have to base their judgments on the product information presented on the web sites. In addition, due to huge amount of data present on the online shopping website it would be difficult for the consumers to select items that suit their preference. As a consequence, web interface design plays a significant role in affecting consumers' online shopping performance and attitude toward the web site.

Interactive evolutionary algorithms (IEAs) are a class of evolutionary algorithms (EAs) which can find optimal solutions for problems where the objective function cannot be explicitly defined. In other words, IEAs try to obtain the objective value from the user. In traditional IEAs, the user is asked to provide a rank to each solution or to explicitly choose best solutions using a computer mouse. Evaluating each population member over a few generations is not an easy task and would result in human fatigue. Recently, researchers try to use the time gaze information obtained from an eye-tracker to automatically order a set of solutions that are displayed on a screen. In other words, the gaze information reflects personal taste of the individual human subjects.

In this paper, we present propose a system which can recommend a variety of clothes by understanding the human preference. In the proposed system, the human preference is measured based on the eye gaze information (fixation length and fixation count) and used as fitness value in the IEA. Based on the current models, new models are generated by using the mutation operation of IEA.

The paper is organized as follows. Section II presents a literature review on the eye-tracking based IEAs and the recommendation systems. Section III presents the proposed model. Section IV presents the experimental setup and the results while Section V concludes the paper.

II. Literature Review

A. *Eye-tracking based Interactive Evolutionary Algorithms*

EAs such as genetic algorithm, genetic programming, evolution strategy, or evolutionary programming (EP) are based on natural evolution mechanisms such as crossover, mutation and selection based on survival of fittest. EAs start with a set of randomly generated initial solutions called population which evolves iteratively to optimize a given criteria [1].

In classical EAs, an explicitly defined mathematical expression called the *fitness function* is employed to express the quality of the candidate solution and in selection. However, in applications such as design and art [2] it is difficult to express the human aesthetics or preference in the form of a mathematical expression. For instance, if we want to design a system which produces "good designs of clothes" according to human preferences then it would be difficult to express the human preference in the form of an expression. The difficulty is because the "good designs" are subjective and defer from subject to subject. In addition, for a given design the preference level or the fitness value changes depending on the other designs which are displayed on the screen at the same time. In other words, the fitness values provided by the human subjects may not be consistent.

IEAs are similar to EAs except that the fitness value of each individual in the population is provided by the human subject instead of a predefined objective function [3]. In other words, IEAs can 'interact' with users and can reflect personal preference or changing fashion, because it percepts fitness directly from user instead of a predefined function. Therefore, IEAs try to optimize the user's emotion or preference in the course of evolution. However, IEAs encounter problems such as 1) *inconsistencies* of individual fitness values given by the user, 2) *slowness* due to the interactivity and 3) *fatigue* of the user due to the obligation to evaluate manually all the individuals of each generation [4]. For instance, the user is often asked to give a mark to each individual or to select the most promising individuals: it still requires active time consuming participation during the interaction. Recently, the authors in [5] propose a framework which aims at reducing user fatigue by using an eye tracker. By employing the eye tracker, the human subject has to just watch the images corresponding to the different solution individuals to provide a rank to each individual or explicitly choose the best solutions. In other words, the eye-tracking systems can analyze and provide information regarding the attention point of the user without much effort and in a completely non-restrictive manner.

B. Recommendation Systems

In [6], the authors developed a fashion design aid system using genetic programming. A number of lengths from a dress were encoded into the chromosome and the system evolves each dress design according to user's selection. However, most of designs developed by the system were somewhat impractical, because encoded individuals did not contain realistic knowledge on the domain of fashion.

In general, computer aided design support systems based on traditional artificial intelligence analyses the behavior or the designer statistically to extract formal design behavior. However, this approach cannot deal with continuous change of fashion and do not reflect the personal taste well. In [3], the authors propose a fashion design aid system for non-professional using domain specific knowledge to encode genotype of an interactive genetic algorithm. Unlike the previous works that attempt to model the dress design by several spline curves, the system in [3] is based on a new encoding scheme that practically describes a dress with three parts: body and neck, sleeve, and skirt. By incorporating the domain specific knowledge into the genotype, the system was able to develop more realistic designs of women's dress. The system was implemented with OpenGL and VRML to enhance the system interface.

III. PROPOSED SYSTEM

The eyes and their movements are frequently described as a "window to the mind" [7]. In other words, when several images are presented simultaneously there exists a correlation between accumulated fixation time and the viewer's preference for one image over others [8]. EAs based on Darwinian Theory of evolution try to localize highly fit solutions.

The empirical study of the aesthetic experience is not easy due to the complex interaction of many individual features on the aesthetic evaluation of the stimulus [7]. In [9], it has been shown that evolutionary algorithms, which provide a robust method for searching complex feature spaces for highly fit interactions, can be used to answer questions relating to aesthetic preference, using the time spent fixating each image in a simultaneously presented array as a measure of fitness. They propose an oculomotor signature which correlates with selections based on visual aesthetic preference using a wide range of photographic stimuli, with a view to integrating the signature as a fitness measure in the gaze-driven evolutionary algorithm to facilitate the aesthetic evaluation of complex visual stimuli without the need for conscious articulation of that preference. In other words, the association between the task being performed and the eye movements made while performing the task is well established.

In the present work, we developed an interactive evolutionary programming based recommendation system which evolves and recommends new designs to the user according to the human preference. The outline of the proposed system is shown in Fig. 1.

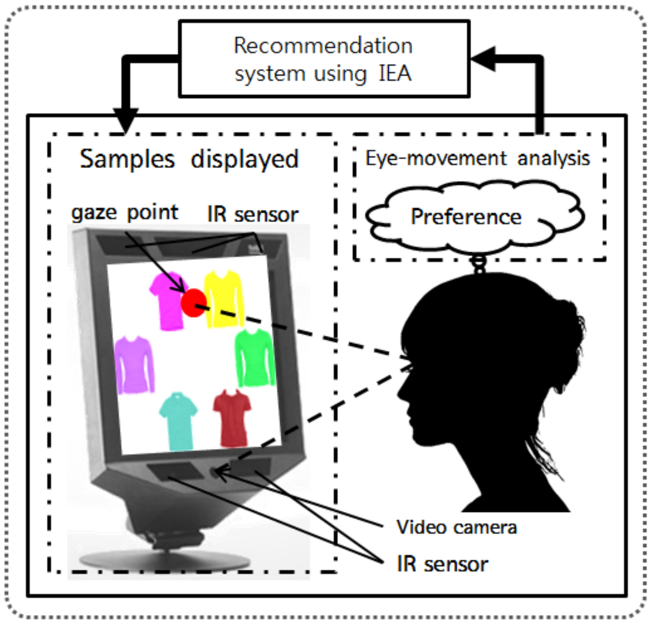

Fig. 1 Overview of Proposed System

As shown in Fig.1, the proposed system comprises of 1) eye-tracking system to measure the human preference 2) a recommendation system based on interactive evolutionary program. First the sample stimuli (phenotypes) are displayed on the screen and the eye movements (fixation length and fixation count) corresponding to each stimulus is measured to provide a fitness value. Based on the fitness values, the "fittest" genetic representations (genotypes) corresponding to the visual stimuli displayed are used to generate new "offspring" for the next generation.

The eye-tracking based interactive evolutionary programming can be described by the following steps.

Step 1: Initialize a set of N solutions called parent population

Step 2: Evaluate the fitness of the solutions in the population using a fitness function

Step 3: Generate a set of N new solutions called offspring population using mutation

Step 4: From the set of parent and offspring populations select N solutions based on fitness to form the parent population for the next generation

In the present work, the eye-tracking system can analyze user preference using fixation length, fixation count and gaze position. The eye-tracker detects the user eyeball and calibrates eye-position using IR sensor of human subject in front of it. Based on the work done in [10], a combination of eye-movement statistics which correlate with human aesthetic preference is used as the fitness function to rank and select the candidate solutions. In other words, the fitness is the proportion of time spent fixating on the phenotype, weighted according to the sequence of first fixations (later first fixations weighted stronger) and number of re-fixations [7]. The calculation of the fitness is as follows.

$$a_i = w_i C_i \qquad (1)$$

$$w_i = \frac{s_i + r_i}{2} \quad \text{and} \quad c_i = \frac{f_i}{F} \qquad (2)$$

where

f_i - Amount of time spent fixating i-th image
F - Total time spent fixating on all images
C_i - Cumulative fixation for each image.
s_i - Order of the first fixation of image i.
r_i - number of returns to image i.
w_i - weighting factor that represents the sustained interest on an image following its initial fixation.
a_i - weighted relative cumulative fixation duration scaled according to sustained interest and represent the aesthetic preference of the human subject.

Generally, the values of C_i, s_i and w_i are in the range of 0 to 1.

IV. Experimental Setup and Results

The system runs on quad core cpu PC. During each generation of the evolution 6 clothes are displayed on the screen. In every generation, the user preference is estimated by measuring the fixation count and fixation length of the human subjects. The fixation length and fixation count are measured using Tobii 1750 eye tracking system (www.tobii.com). The Tobii system detects eye movements via a camera located underneath the monitor's screen, near infrared diodes and detectors to detect reflection patterns on the corneas. The system processes information using sophisticated image processing algorithms in the software to identify relevant features.

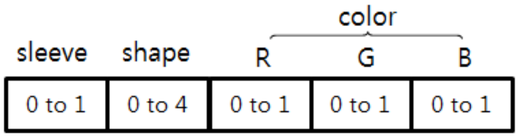

Fig. 2 Dress parameters

Fig. 3 Different dress shapes

In the present work, each dress displayed on the screen consists of five parameters. The composition of the solution vector and the range of the parameter values are shown in Fig. 2. First parameter is sleeve style while the second parameter is neck style. The remaining three parameters are used to represent the color of the dresses. The next three parameters represent the R, G and B values. In the present work, the color of the clothes recommended by the system consists of a single uniform color. We employ only two sleeve styles and five different neck styles as shown in Fig. 3. The human subjects are asked to stop the experiments once they obtain a dress that matches their preference.

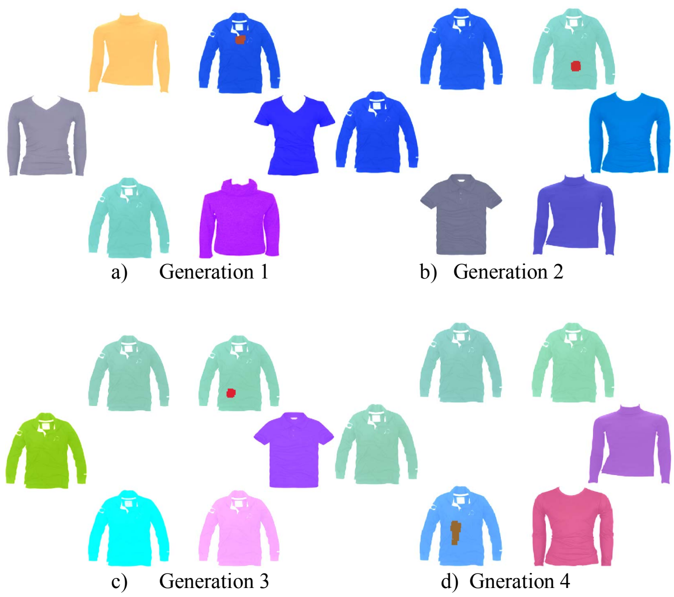

Fig. 4 Dresses during different generations of the evolution

The experiments were done employing 20 human subjects. Fig. 4 shows how the dresses evolve during different stages of the evolution. In Fig.4, in each generation the dress with the red dot indicates the dress the human subject likes. From Fig.4, it can be observed that the individual dresses in the final generation (Generation 4) matches the preference of the user and the dresses suggested by the recommendation system during the different stages of the evolution match the human preference. In addition, the convergence characteristics in Fig. 5 show the improvement in the overall fitness during the evolution for different subjects. Due to the space constraint we present the convergence characteristics of experiments corresponding to six different subjects.

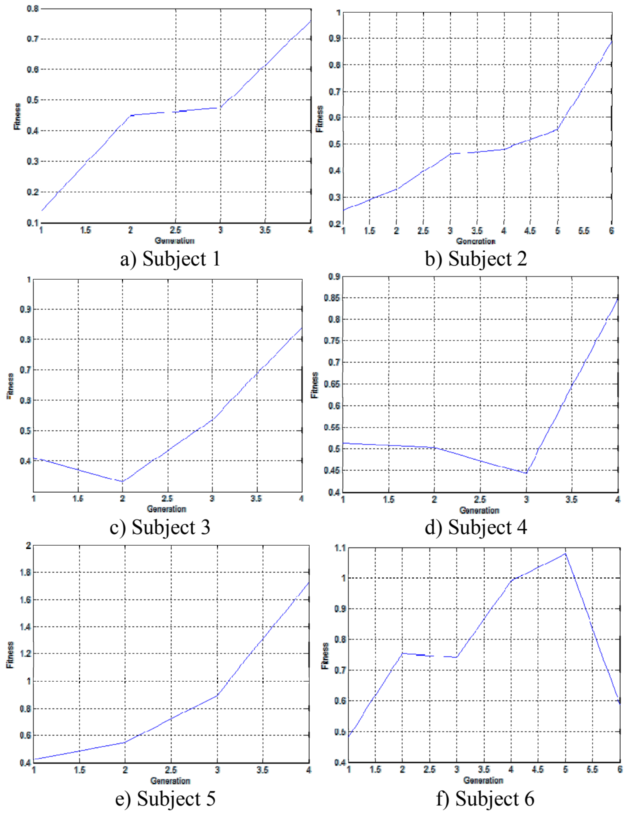

Fig. 5 Convergence characteristics

V. Conclusions

In this paper, we developed a recommendation system that can recommend clothes to human subjects based on the preference. The proposed system understands the human preference based on the eye movement analysis and suggests the clothes based on interactive evolutionary programming. The proposed system is evaluated using healthy human subjects. The results clearly show that the proposed system is able to estimate the human preference accurately and suggests clothes are more close to the human preference.

As a future work, we intend to extend our framework by adding few more parameters that make-up the dresses. In addition, we would like study the proposed system by testing on a huge set of human subjects.

Acknowledgment

This research was supported by the Original Technology Research Program for Brain Science through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2013-034988) (50%) and also the Industrial Strategic Technology Development Program (10044009) funded by the Ministry of Knowledge Economy(MKE, Korea) (50%)

References

[1] A. P. Engelbrecht, *Computational Intelligence: An Introduction*, Second ed.: John Wiley, 2007.

[2] H. Takagi, "Interactive Evolutionary Computation as Humanized Computational Intelligence Technology," in *Computational Intelligence. Theory and Applications*. vol. 2206, B. Reusch, Ed., ed: Springer Berlin Heidelberg, 2001, pp. 1-1.

[3] H.-S. Kim and S.-B. Cho, "Fashion Design Using Interactive Genetic Algorithm with Knowledge-based Encoding," in *Knowledge Incorporation in Evolutionary Computation*. vol. 167, Y. Jin, Ed., ed: Springer Berlin Heidelberg, 2005, pp. 411-434.

[4] H. Takagi, "Interactive evolutionary computation: fusion of the capabilities of EC optimization and human evaluation," *Proceedings of the IEEE,* vol. 89, pp. 1275-1296, 2001.

[5] D. Pallez, M. Cremene, T. Baccino, and O. Sabou, "Analyzing human gaze path during an interactive optimization task," presented at the Proceedings of the 2010 workshop on Eye gaze in intelligent human machine interaction, Hong Kong, China, 2010.

[6] Y. Nakanishi, "Capturing preferene into a function using interactions with a manual evolutionary design aid system," presented at the Genetic Programming Late-Breaking Papers, 1996.

[7] T. Holmes and J. M. Zanker, "Using an oculomotor signature as an indicator of aesthetic preference," *i-Perception,* vol. 3, p. 426, 2012.

[8] M. Glaholt and E. Reingold, "Stimulus exposure and gaze bias: A further test of the gaze cascade model," *Attention, Perception, & Psychophysics,* vol. 71, pp. 445-450, 2009/04/01 2009.

[9] T. Holmes and J. Zanker, "Eye on the prize: using overt visual attention to drive fitness for interactive evolutionary computation," presented at the Proceedings of the 10th annual conference on Genetic and evolutionary computation, Atlanta, GA, USA, 2008.

[10] T. Holmes and J. Zanker, "I like what I see: Using eye-movement statistics to detect image preference," *Journal of Vision,* vol. 9, p. 385, August 5, 2009 2009.