Using Interactive Genetic Algorithm for Bundle Design

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Abstract

To respond to changing and diversifying customer requirements, a system for supporting industrial design, where a customer can personally participate in the design process, is proposed. This study applied Interactive Genetic Algorithm (IGA) in the design of bundles to maximum the consumer's perceived value. In the human fatigue problem, we propose a hybrid method called Hybrid Interactive Genetic Algorithm (HIGA). We combined Simple Genetic Algorithm (SGA) and IGA to relax the limitation on the number of generations and the population size. By adding SGA into one of the IGA phases, we can calculate the bundles' profits with a simple fitness function and consider the benefit of cooperation in the design stage. We also propose another method named Improved Interactive Genetic Algorithm (IIGA) to embed the consumer's intention in this search. To demonstrate the effectiveness of our system, we applied it to the design of MP3 bundles including MP3 players, earphones and lanyards.

Keywords Bundle; Genetic Algorithm(GA); Interactive Genetic Algorithm(IGA); perceived value; Hybrid Interactive Genetic Algorithm(HIGA); Improved Interactive Genetic Algorithm(IIGA)

1. Introduction

In recent years, with awakening customers, each industry is gradually shifting from product -oriented to customer-oriented epochs. Organizations are facing challenges on customer relationship management. How to cope with these problems would be another challenge to an organization's managers, and the final winners are those who could transform challenges into opportunities. Consequently, organizations have to emphasize personalization as well as customized products and services to satisfy different marketing segments in various requirement levels.

Recently, Interactive Genetic Algorithm (IGA) researches have expanded into the fields of fashion design and other practical ones (Kim and Cho, 2000; Takagi, 2001). Although the IGA has been widely used, the most important problem of IGA applications is to reduce human fatigue. This problem is related to that how to search for a goal with a smaller population size within a fewer number of searching generations. The IGA population size is limited by the number of individual images that are displayed on a computer monitor or by the human capacity to remember images. The searching generation is also limited by human fatigue.

In this study, we develop a bundle design system with IGA and using two improving methods to reduce IGA users' fatigue. One approach to solve the problem is to combine with Simple Genetic Algorithm (SGA) to enlarge the population size and searching generations. Another approach is to use on-line knowledge embedding that provides a mechanism for accepting searching ideas, hints, or intentions during the IGA operation (Takagi, 1999).

2. Literature review

2.1. Bundle

Bundling, the strategy of marketing two or more products and/or services as a "package" at a special price is a common marketing tactic (Guiltinan, 1987). Yadav and Monroe (1993) indicated that the effect size of perceived bundle savings exceeds that of perceived item savings. Harlam et al. (1995) specify that bundles composed of complements have a higher purchase intent than bundles of similar or unrelated products.

2.2. Genetic Algorithm

Genetic Algorithm (GA) was proposed by John Holland in 1975. GA is a model of machine learning derived by the theory of natural evolution mechanisms like crossover, mutation, and survival of the fittest (Holland, 1975). The most common application of GAs is multi-parameter function optimization especially in searching high dimensions, non-linear and discontinuous search spaces.

2.3. Interactive Genetic Algorithm

Interactive Evolutionary Computation (IEC) is a technology that embeds human preference, intuition, emotion, psychological aspects, or a more general term, KANSEI, in the target system(Takagi, 2001). IGA is one of the IEC concepts. It is the same as GA except for the fitness function.

IGA adopts user's preference as fitness instead of fitness function, when fitness function cannot be exactly determined. IGA was applied to the fields of graphic art (Iwasaki et al., 2000), speech processing (Watanabe and Takagi, 1995), fashion design (Kim and Cho, 2000), etc. For example, Caldwell and Johnston applied it to criminal suspect tracking system (Caldwell and Johnston, 1991).

2.4. Why Hybrid IGA and Improved IGA

Although the interest of IGA has been progressively increased, this technology still has a common problem with these applications: the fatigue with IGA users. This problem extends to two issues: (1) How to search for a goal with a smaller population size within a fewer number of searching generations? (2) How to improve the fitness evaluation to ease users' psychological and physical fatigue? In order to solve the first issue, we propose the Hybrid Interactive Genetic Algorithm (HIGA) that combines SGA with IGA to increase the searching capability by using a large population size and enough searching generations.

Furthermore, the fitness function of SGA phase can calculate the bundles' profits. For the second issue, we suggest the Improved Interactive Genetic Algorithm (IIGA) that allows an IGA user to directly participate in IGA searching phases. For example, when a user feels that a certain part image of a MP3 bundle is acceptable, we fix the partial component image in subsequent searches, which limits the searching space and, therefore, converges faster.

3. Research Method

3.1. System Design

Fig. 1 shows the overview of the entire system. The IGA phase selects the models of each part and combines them into some individual bundles. After six individuals are displayed on the screen, user gives fitness values to each bundle.

Then, system will put these values into IGA phase, and the natural evolution mechanisms will begin to create the next generation. Results are displayed again on the screen. The system will repeat this process to search for better bundle designs until the user finds out the image that he prefers. In the next section, we will introduce the three bundle design systems proposed in our research: HIGA, IIGA, and a conventional one.

3.2. IGA phase

- Hybrid Interactive Genetic Algorithm (HIGA)

The bundle design system with hybrid method has the same operation steps as conventional one. The difference is that we combine SGA with IGA phase to improve the convergent performance by enlarging the population size and increasing searching generations. This method implements the IGA once every fifty SGA generations.

- Improved Interactive Genetic Algorithm (IIGA)

The refinement based on HIGA, IIGA method includes the on-line knowledge embedding strategy. For example, if a user thinks that the impression of earphone was similar to those in their memory, they would check the earphone item. Then, the earphones of all the bundles in the following search generations become the chosen earphones. In this way, it can reduce the number of dimensions of searching space from five to four and accelerate the searching convergence.

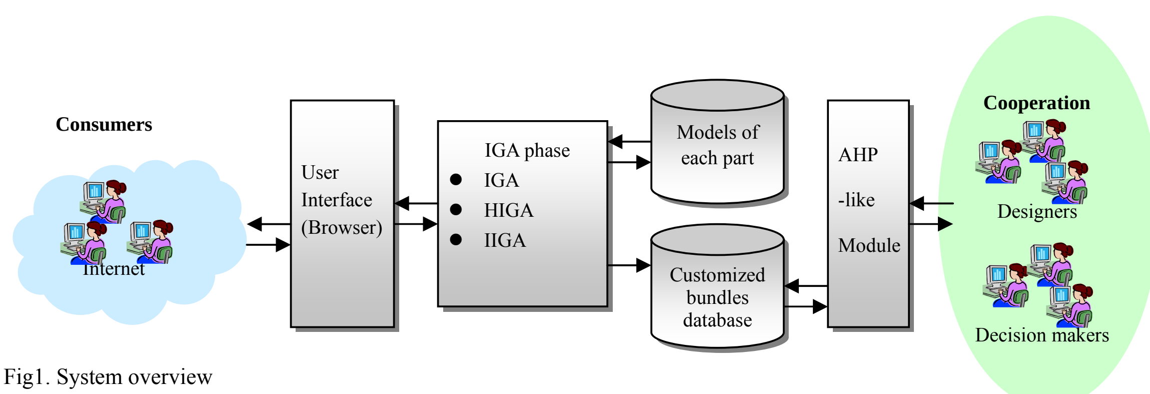


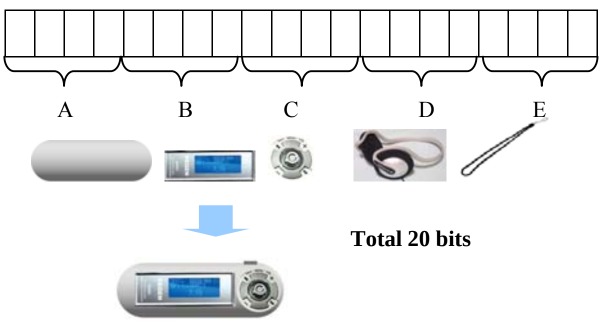
Fig1. System overview

3.3. AHP-like module

Although we can get a customized bundle that user prefers, personalized marketing is costly for cooperation. Further, the designers of cooperation can evaluate the bundles that consist with consumers' perceived value via a AHP-like moudle. Finally, we market a few bundles that correspond to enterprise's benefit and consumers' perceived value.

3.4. Chromosome encoding

Our bundle design systems generate images of a bundle by combining five different part images: MP3 player's panel, MP3 player's monitor, MP3 player's button, earphone, and lanyard. We have encoded them with four bits for each. Fig. 2 describes how a chromosome is completely encoded. We can calculate the possible number of synthesized bundles is $16^5 = 1{,}048{,}576$. Our system's task is to search the best design out of 1,048,576 candidates according to user's feedback on preference and emtion.



A□MP3 player — panel
B□MP3 player — monitor
C□MP3 player — button
D□Earphone
E□Lanyard

Fig.2 Chromosome encoding

4. Experiments

In order to evaluate two methods that we proposed to improve the performance and convergence speed of IGA, we design three different IGA experiments.

- Experiment I IGA
- Experiment II HIGA
- Experiment III IIGA

4.1. Participants

Participants were chosen from MBA and EMBA students of Department of Information Management, Fu-Jen University. We decided to use the laboratory experiment. Because of the long operation time, we ask for volunteers who interest the experiment.

4.2. Procedure

- For human fatigue, we will arrange for the same group in different date to operate different systems.
- First, the researcher will explain the procedure of the system.
- Second, subjects will fill the personal data and follow the instruction to contiune the interactive phase.In the IGA interactive phase, subjects have to give the fitness value to each individual bundle(see Fig3).
- During the time of operate, user should answer a short questionnaire which ask the number of similar parts for every 5 generation.
- Finally, the system will record the operation time automatically and collect user's satisfaction of a bundle by questionnaire.

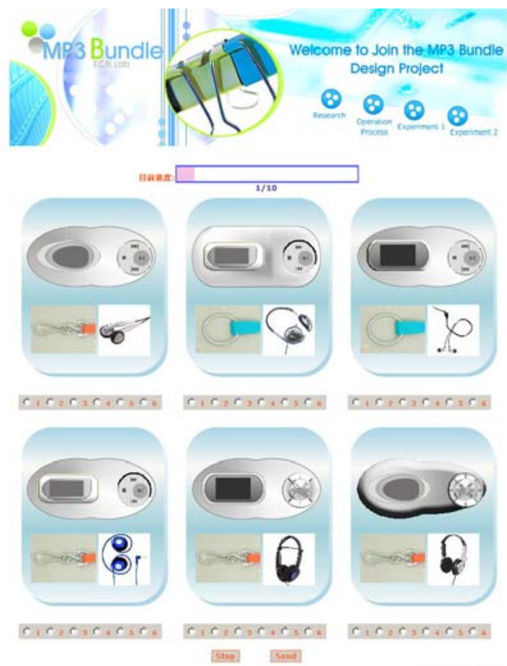


Fig.3 The user interface of a bundle design system.

4.3. Experimental evaluations

We will compare three bundle design systems in convergent performance and efficiency aspects.

- Performance analysis

  Systems will record the operation time and fitness value automatically for every generation.
- Efficiency analysis

  (1) *Comparison of satisfaction*: After operating the three systems, subjects will be required to compare the best generated bundles of each system and choose the better one.

(2) *Comparison of the number of similar part-images*: Takagi and Kishi (1999) indicated that it is difficult to measure the similarity and weights. For this reason, they use the number of selected correct part-images as the performance index of how a similar face image is generated. We refer to this method and design the performance evalution that part-images of genreated faces in 5th and 10th generations would be compared with those of the target bundle, and the numbers. For example, if the monitor of MP3 player and the earphone correspond to user's expectation, the number of similar part-images is two. If the more number of similar part-images we have, the better our systems perform.

5. Discussion

Using HIGA and IIGA have improved both users' preceived value and cooperation's benfit. The bundle design support system would help us to respond diversifying customer's requirements and acquire the satisfaction and the loyalty of customers. Besides, we expect contribute to the research field of IGA by proposing the strategies to improve the human fatigue.

6. References

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