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STIMULATIVE MECHANISM FOR CREATIVE THINKING

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ABSTRACT:

The objective of this research is to present the creative stimulation system for designers. The major purpose behind this research was to assess the feasibility of using a computational mechanism to stimulate designers' creative thinking via interaction with a computer during the design process. The practicality of the proposed methodology involved a creative stimulation approach based on the morphological analysis method and an evolutionary computation system, and integrating an interactive genetic algorithm into the mechanism to generate an interactive creative stimulation system. Affective design of the shape of mobile phones is used as an implementation example.

Keywords: Interactive Creative Stimulation System, Creative Evolutionary Computation, Interactive Genetic Algorithm

1. INTRODUCTION

In recent years, there have been a number of studies that investigated design methods using systematic modes of thinking with a stimulation approach to help designers derive a great quantity of creative ideas in a short time (Janssen, 2006; Lin and Liu, 2005; Chou, 2004; Cho, 2002). In particular, in the current highly competitive market, applying new techniques to creative thinking to generate creative ideas rapidly for marketing is an emerging trend and strategy in the design field. Thus, how to stimulate creativity of designers based on marking knowledge via a computational mechanism has become a new area of focus. The purpose of this paper, therefore, is to present a computational mechanism that supports creative stimulation for designers.

In view of the research purpose mentioned above, the major questions addressed in this study are: (1) What is the definition of creativity? (2) How do human beings do creative work in the real world? (3) How can design knowledge be retrieved from marketing? (4) What approaches can stimulate creativity? (5) How can a computational mechanism support such work? The rest of the paper is structured as follows. The second section deals with the theoretical foundations on creative approaches and the related computational technologies for the development of the research. After that, the research methodology is presented, including the creative stimulation approach, knowledge retrieval system, and integrated mechanism and model. The system architecture and a set of operating interfaces of prototype software are then described for the research implementation.

2. BACKGROUND REVIEW

2.1 CREATIVITY IN THE DESIGN PROCESS

Design as one of the most creative of human pursuits, as seen from the designer's perspective, is a series of amazing imaginative jumps or creative leaps (Frazer, 2002). In creativity in design, the whole point of the business is to create something which other people will experience and which is in some way or other original and new (Lawson, 2006). Thus, the definitions of creativity in design involves the transfer of knowledge from other domains, having the ability to generate "surprising and innovative solutions", or the creation of "novel solutions that are qualitatively better than previous solutions" (Gero and Kazakov, 1996). Rosenman (1997) also pointed out that "The lesser the knowledge about existing relationships between the requirements and the form to satisfy those requirements, the more a design problem tends towards creative design".

2.1.1 Acquisition Approach to Design Knowledge

Subjective assessments are commonly used to evaluate and acquire design knowledge. Osgood et al. (1957) proposed the semantic differential (SD) method, which is one of the most frequently used procedures for obtaining meaning space from samples by investigation using a qualitative scale mapping numerical relationships between the samples and the related words, and converting them into numerical data (Jiao, et al., 2006; Khalid and Helander, 2004; Osgood, et al., 1957). Many researchers have used this method to study specific aspects of design problems.

2.1.2 Morphological Analysis (MA) Method

Morphological analysis (MA) is a creative method proposed by Fritz Zwicky in 1967 for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable, problem complexes. In the MA method a target problem is divided into many parts, which generate many independent variables as the components. Then, the user acquires new concepts by combining independent variables. This method is the most understandable and usable for designers in design work. MA defines the problem in terms of all relevant, independent variables present, searching for useful permutations and combinations of these variables which show promise for the development of a superior solution (Alomar, 2003). There are five steps that need to be performed in MA as follows: (1) Describe, define, and generalize the problem. (2) Define all factors that influence the solution. (3) Structure these factors into distinctive categories. (4) Analyze the cells at the intersection of each category with every other category. (5) Evaluate each of these cells in terms of the solution criteria.

2.2 CREATIVE DESIGN BY COMPUTER

For a long time, people have not believed that creativity can be generated by computer. The earliest development in creative design by computer was from Stiny, Mitchell and Frazer (Frazer, 2002; Michie and Johnston, 1984). More recently, a growing number of research studies have shed some light on creative design via compute (Cho, 2002; Bentley and Wakefield, 1996).

2.2.1 Evolutionary Computation Approach in Creativity

An evolutionary approach can be applied in both the process and the outcome of design. In the process of design, evolution can be applied in different stages of design. The evolutionary approach is more consciously, faster, and paradigmatically different than before without evolutionary computation. Clearly, the combination of creativity and evolution is very natural, and evolutionary computation and human creativity make excellent partners (Bentley and Corne, 2002a).

2.2.2 Interactive Genetic Algorithm (IGA)

Genetic algorithms (GA) were first proposed by John Holland in the early 1970s. They are a class of algorithms based on the adaptive process of natural evolution, employing a general uniform knowledge-lean methodology (Rosenman, 1997). They are applied to a natural evolution mechanism like crossover, mutation, or survival of the fittest for optimization and machine learning. GAs provide very efficient search methods for working on population, and has been applied to many problems of optimization and classification. Interactive Genetic Algorithms (IGA) are the same as GAs except for the way of assigning the fitness value. The major difference between IGA and GA is how to determine the fitness values of each evolvable individual. In general, a GA assigns a fitness value to an individual via evaluating a predefined fitness function. However, formulating the fitness functions of the optimization solutions concerning user preferences in advance is very difficult. In an IGA, the user gives a fitness value instead of a fitness function to each individual. In this way the IGA can ‘interact’ with the user, and can also perceive a user’s emotion or preference in the course of the evolution. For this reason IGA can be used to solve problems that cannot be easily solved by GA, such as design and art. In fact, IGA has been reported to have been successfully applied in cases of art design, industrial design, and product design (Wang, et al., 2005; Cho, 2002; Takagi, 2001). Figure 1 compares the processes of GA and IGA.

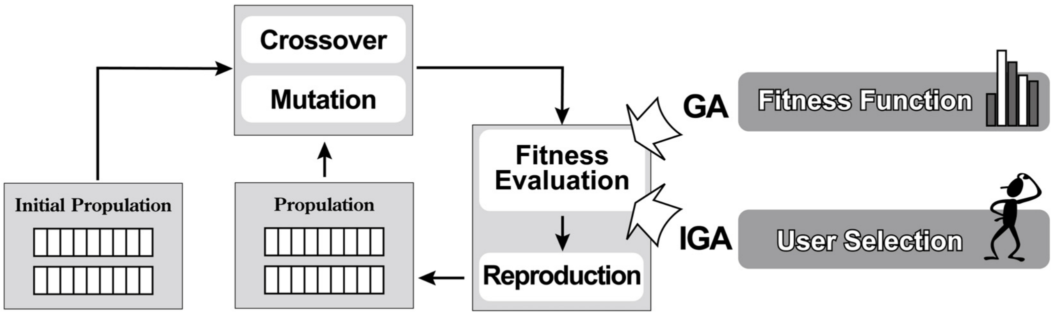

Figure 1: GA and IGA process (Re-draw from (Kim and Cho, 2000)).

The basic algorithm of an IGA is as follows: (1) The computer generates some individuals as the initial population. (2) The computer mates the individuals and generates new individuals as children by applying crossover or mutation. Then, they are presented to the user. (3) The user evaluates the individuals proposed by the computer. (4) Based on evaluation by the user, the computer selects the individuals as survivors for the next generation. (5) Going back to (2). This process is repeated until the terminal condition is satisfied.

2.2.3 Creative Evolutionary System (CES)

Art, music, and designs have been emerging from computers for many years. Moreover, computer creativity has been quietly slipping onto our screens and edging into our consciousness. A new approach to evolution not only has been used and explored with creative products in view, but has also added to the computer creator's armory. Therefore, evolutionary systems are a promising technique for such enterprise, recently growing in favor (Bentley and Corne, 2002b).

The Creative Evolutionary System (CES) is the latest software solution for the relatively unexplored area of human creativity (Bentley and Corne, 2002a). The main feature that all creative evolutionary design systems have in common is the ability to generate entirely new designs starting from little or nothing, guided purely by functional performance criteria. In achieving this, such systems often vary the number of decision variables during the evolution process (Rosenman, 1997). They can often generate surprising and innovative solutions, or novel solutions qualitatively better than others (Bentley, 1999; Harvey and Thompson, 1997).

The CES requires some kind of evolutionary algorithm to generate new solutions. The framework of the CES is as follows: (1) an evolutionary algorithm; (2) a genetic representation; (3) embryogenesis using components; (4) a phenotype representation; and (5) fitness function(s) and/or processing of user input.

3. METHODOLOGY

3.1 CREATIVE STIMULATION APPROACH INTEGRATING MA AND CES

Based on the foundational theories of MA and CES, an integrated model illustrating the creative stimulation approach is shown in Figure 2. According to the MA method, CES plays the role of computation support. For each stage of the MA process, CES encodes factors into a genetic representation; the evolutionary algorithm provides the generation mechanism to produce the possible solution's parameters; the fitness function gives the mode to the evaluation stage; embryogenesis helps the construction stage; and phenotype is used for decoding to represent the generative idea.

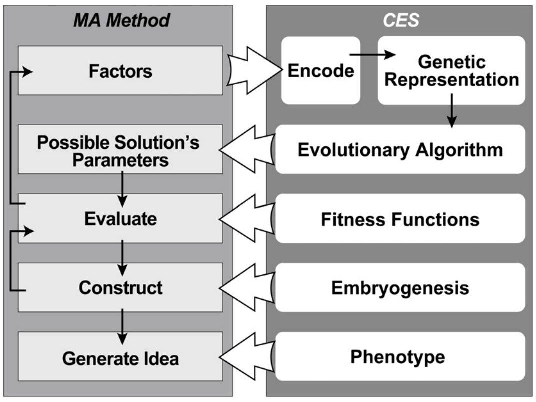

Figure 2: Diagram of creative stimulation approach.

3.2 MOBILE PHONE SHAPE AFFECTIVE DESIGN EXAMPLE AND RETRIEVAL SYSTEM

We built a retrieval system for analysis of shape affection. The major methodology behind this system is the SD method using mathematical notation to measure stimuli (Chang and Lee, 2007). In this manner, we used well-known affective words relating to mobile phones to evaluate customers' affective response to the shapes of mobile phones. The affective analysis engine provided the mechanism to analyze the relationship between affective response and the shape of mobile phones. Figure 3 show the interface and structure of the retrieval system on the right-hand side.

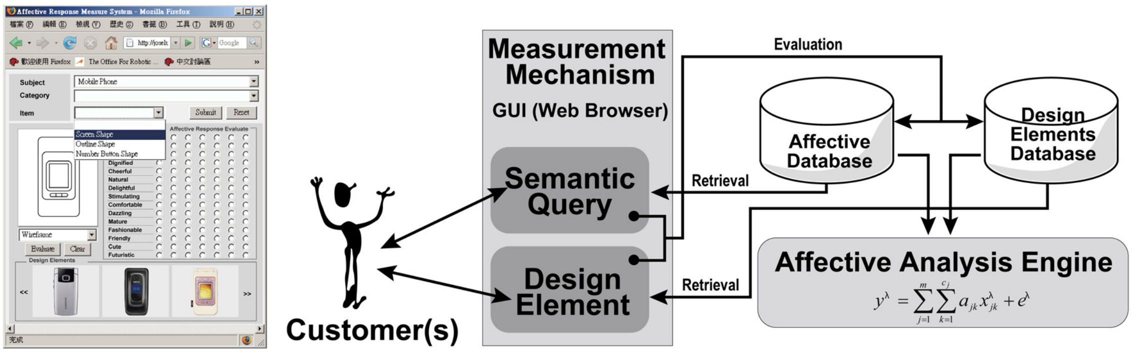

Figure 3: Interface and structure of affective shape retrieval system (from Chang and Lee, 2007).

3.3 INTERACTIVE GENETIC ALGORITHM (IGA) AS A GENERATIVE TOOL

According to the creative stimulation approach which integrates the MA method and creative evolutionary system, GA is the most well known and popularized of all evolution-based approaches (Bentley and Corne, 2002b). In order to enhance the stimulation of the interaction between the designer and computer, IGA is particularly suited as it can be used to interact with the designer and also perceive the designer's emotion or preference in the course of the evolution.

3.3.1 Genetic Representation and Initialization

Based on the features of the mobile phone, the genotype of the initial individuals involves the outline, screen, navigation key, number key, and microphone parts. There are two sub-genotypes to categorize component shapes and affective words attached to each individual as shown in Figure 4.

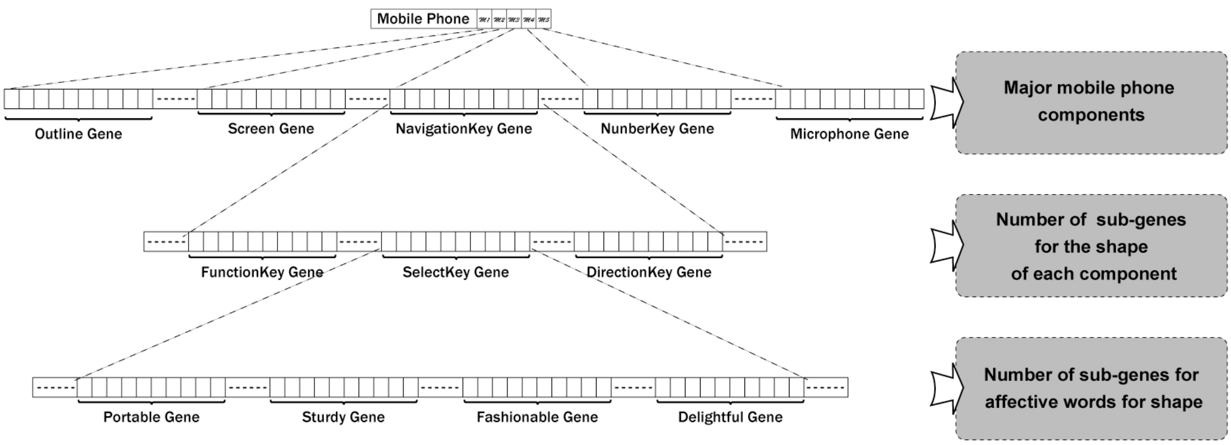

Figure 4: Genotype, sub-genotypes, and setting of initial chromosomes of individuals.

3.3.2 Genetic Operations

Each chromosome is encoded by a bit string. The crossover operation swaps a part of the bit string of the parents. The mutation operation inverts some bits in the bit string at a very low rate. Figure 5 shows how the crossover and mutation operations are applied in IGA. Each individual in the population evolves to obtain greater fitness as it evolves from generation to generation.

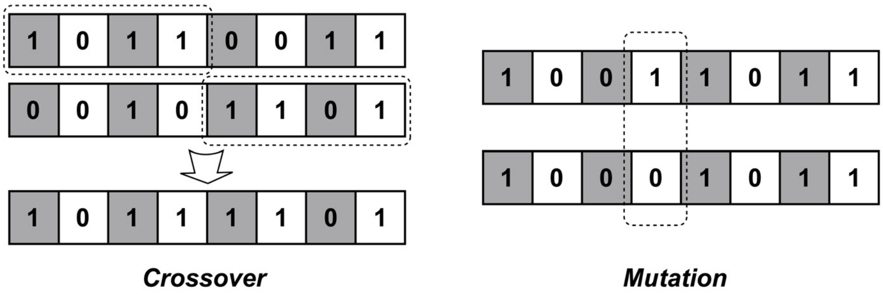

Figure 5: Crossover and mutation operations.

3.3.3 Fitness Function

The fitness function is a mechanism used to evaluate the status of a solution. According to the characteristics of the IGA, we constructed an interactive mode into the graphical user interface. The designer can then evaluate the fitness function using descriptions.

3.4 MODEL OF INTERACTIVE CREATIVE STIMULATION (ICS) SYSTEM

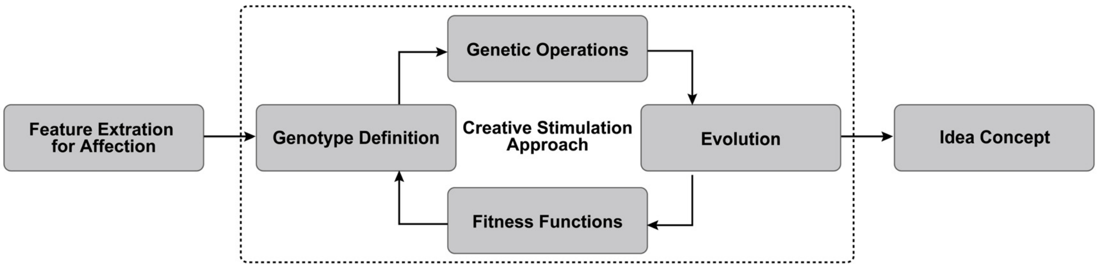

Figure 6: Stages of model for interactive creative stimulation system.

The synthesis model, encompassing all the methods mentioned above, is outlined in Figure 6. The model is the paradigm to implement a proof-of-concept prototype software system called an interactive creative stimulation (ICS) system.

4. PROTOTYPE SYSTEM IMPLEMENTATION

In order to the prove our argument, we built a prototype ICS system. The ICS system comprises a retrieval system for affective response of shapes of mobile phones, a creative evolutionary mechanism, and an IGA. The system architecture is shown in Figure 7.

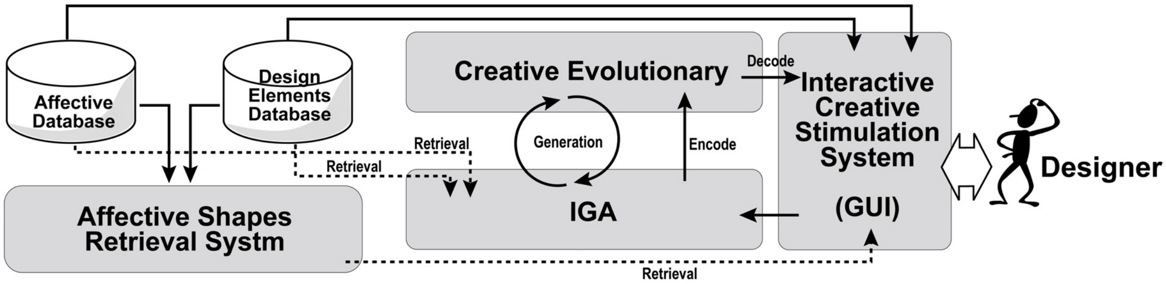

Figure 7: System architecture of ICS system.

The basic operation of the ICS system is as follows: Firstly, the designer selects the design factor for each component of the mobile phone; the system shows the sub-shapes for each component automatically. Secondly, the designer selects the affective requirements to analyze the sub-shapes; the system generates possible solutions for that. Thirdly, according to each solution, the designer evaluates the solution via the fitness function and repeats generation until satisfied. Fourthly, according to each satisfied solution, the designer sends the solutions into a construction mechanism to generate a new idea. Fifthly, according to the generated ideas, the designer evaluates the ideas via the fitness function until satisfied. Finally, the system decodes the results and displays the solution. The operation interface of the ICS system is shown in Figure 8.

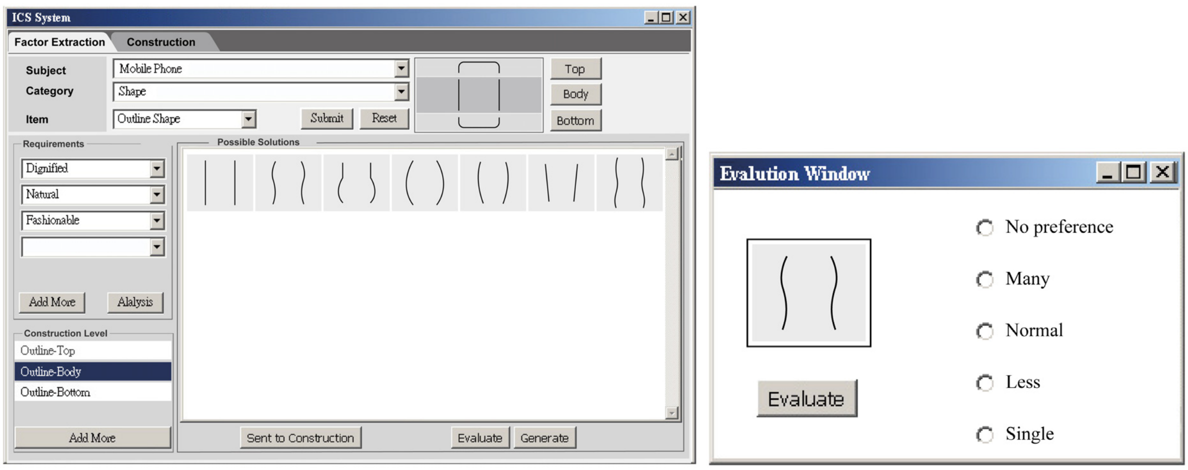

Figure 8: Snapshot prototype interface of ICS system.

5. CONCLUSION

In this paper, we presented a creative stimulation system that supports designers' creative thinking during the design process based on various foundational theories. This paper systematically demonstrated this system using a creative approach, the MA method, and an evolutionary computation system. IGA is the suggestion algorithm in this paper to produce the effect of stimulation through interactive activity. The prototypical computational mechanism can stimulate creative thinking to design-related stakeholders through continuous manipulation of the designer's interaction with the system. We are hopeful that future research will yield further ideas on practical implementation of creative simulation systems. To provide broader creative stimulation support to a wider number of designers, hopefully such systems can be integrated into the current software designers' use in the real world.

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