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An intelligent swarm based-wavelet neural network for affective mobile phone design

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ABSTRACT

In this paper, an intelligent swarm based-wavelet neural network for affective mobile designed is presented. The contribution on this paper is to develop a new intelligent particle swarm optimization (iPSO), where a fuzzy logic system developed based on human knowledge is proposed to determine the inertia weight for the swarm movement of the PSO and the control parameter of a newly introduced cross-mutated operation. The proposed iPSO is used to optimize the parameters of wavelet neural network. An affective design of mobile phones is used to evaluate the effectiveness of the proposed iPSO. It has been found that significantly better results in a statistical sense can be obtained by the iPSO comparing with the existing hybrid PSO methods.

1. Introduction

Recent research demonstrates that particle swarm optimization (PSO) is an effective optimization method to optimize the parameters (or weights) of neural network models [1–8] and industrial applications [9–12]. Although reasonable solutions can generally be obtained by the PSO within a reasonable computational time, enhancement of the operations and the mechanisms of the PSO is essentially required in order to obtain better solutions. A commonly used enhancement approach is to integrate other optimization operations such as gradient descent, crossover and mutation operations into the PSO.

Juang [13] proposed a hybrid PSO algorithm namely HGAPSO which uses evolutionary operations including crossover, mutation and reproduction to control swarm movement, and also a hybrid PSO namely HPSOM was proposed [14] by integrating the PSO with mutation operation. Both HGAPSO and HPSOM inject random components into particles using mutation, but the mutating space used in both approaches is fixed throughout the search. Although premature convergence is more likely to be avoided, the approach can be further improved by varying the mutating space with respect to the searching progress of the PSO. A hybrid PSO with wavelet mutation operation (HPSOWM) was proposed in [15], of which the mutating space varied based on the wavelet theory. By introducing the wavelet mutation, the performance in terms of solution quality and stability can be improved. Although the approaches provide a balance between the global exploration and local exploitation, they are not appropriate to assume that the searching progresses of the PSO are linear or wavelet characteristics, and it is also impractical and almost impossible to mathematically model the searching progress of the PSO, in order to determine the appropriate inertia weight for searching the optimum.

In this paper, an intelligent PSO namely iPSO is proposed to optimize the parameter of variable translation wavelet neural network (VTWNN) [1,3,16] and will be applied to affective design of mobile phones. The iPSO is proposed by introducing two new operations, namely fuzzy inertia weight and cross-mutated (CM) operation. The fuzzy inertia weight is determined based on a fuzzy inference system which consists of a set of linguistic rules in representing the searching characteristics of the PSO. By dynamically changing the fuzzy inertia weight, the dynamic of the swarm can be varied with respect to the searching progress of the PSO. Hence, solutions with better qualities are more likely to be searched. The CM injects momentum to the swarm when the progress of the PSO is saturating, where the amount of momentum is controlled based on the fuzzy inference system. It intends to further avoid the PSO in searching the local optima.

VTWNN is used to model the relationships between design variables and affective responses on mobile design application. Wavelets are used as transfer functions in the hidden layer of the VTWNN. The network parameters, i.e., the translation parameters of the wavelets, are variable depending on the network inputs.

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Thanks to the variable translation parameters, the VTWNN becomes an adaptive network capable of handling different input patterns and exhibits a better modeling performance.

In the development of a new mobile phone, basic functions such as operations of transmission and receiver must work satisfactorily. After these basic functions have been achieved, function operations in a higher level are required to be satisfied. For example, the mobile phone should be felt comfortable when hand-held by the customer. The buttons of a mobile phone should also be pressed easily, and the voices should be clearly heard by the receiver. After satisfying all those functional operations, optimization of affective responses is essentially required [17]. It is now evident in the mobile phone market that successful can transform its products from being merely functional items to lifestyle or fashion accessories [18]. Consequently, product designers are increasingly focusing on optimizing affective responses rather than solely optimizing their functional operations. Therefore, the proposed iPSO is proposed in this paper to optimize the parameters of the VTWNN, in order to perform affective design of mobile phones.

This paper is organized as follows. Section 2 presents the affective mobile design and its morphological matrix. The modeling with VTWNN is discussed in Section 3. The details of iPSO are presented in Section 4. Experimental study and analysis will be given in Section 5 to evaluate the performance of the proposed method. Finally, a conclusion will be drawn in Section 6.

2. Affective mobile design

In the highly competitive market of mobile phones, the product designers provide the consumers with various styles for different brands and different product series of mobile phones. To capture the trend, we have selected 32 recent mobile phones of various brands, including Nokia, Sony Ericsson and Motorola. Morphological analysis shown in Fig. 1 is used to extract representative elements of mobile phones as numerical data sets, in which both the shape profiles and the product components of the mobile phones are used. As shown in Fig. 1, nine representative design elements of the affective design for mobile phones are used, namely "top shape", "bottom shape", "side shape", "function button shape", "number button style", "length width ratio", "thickness", "layout" and "border and frame", where those representative design elements are denoted as $x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8$ and x_9 respectively. Those representative design elements were identified from the 32 mobile phone samples. The number 1–6 of

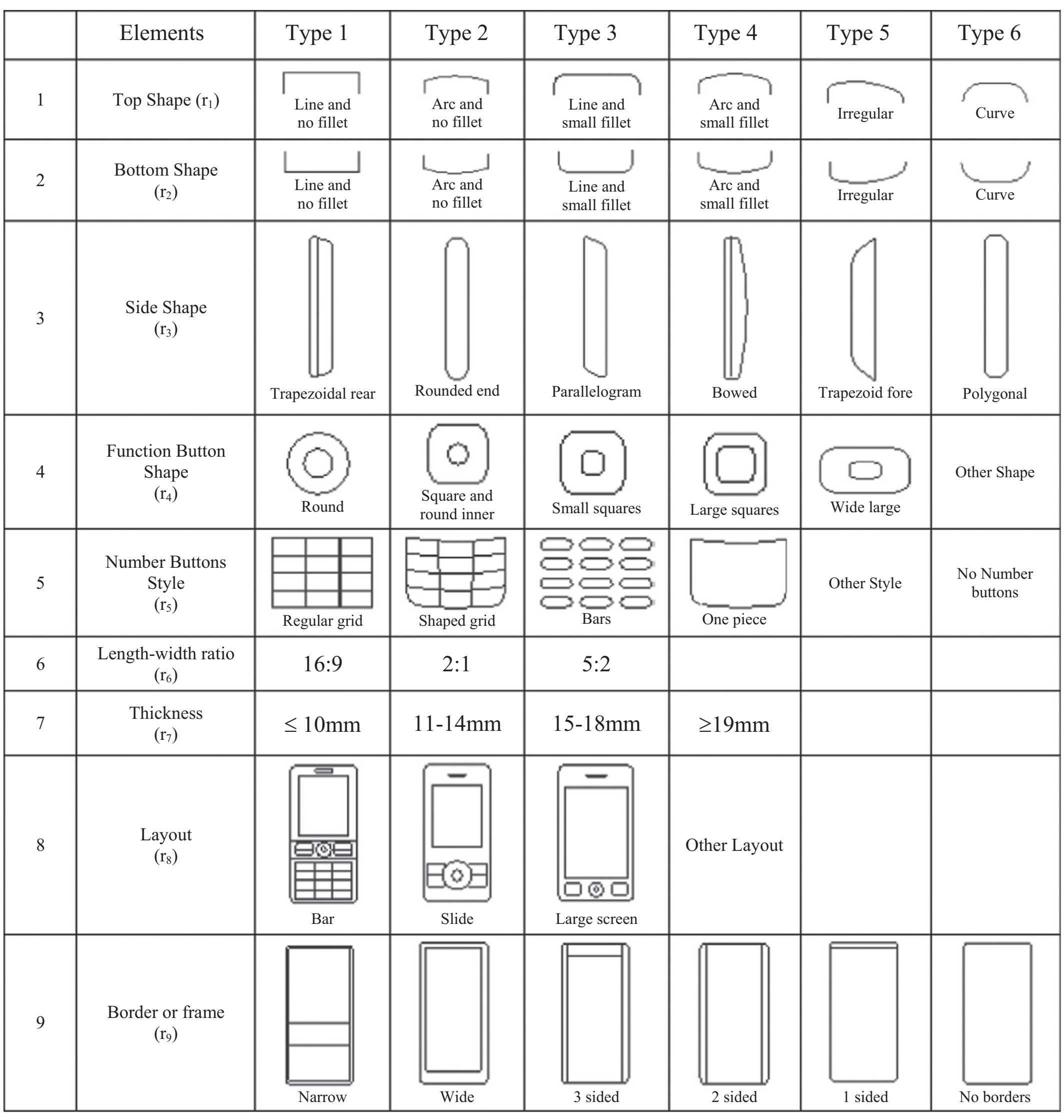

Fig. 1. Morphological analysis on the 32 representative mobile phone samples.