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Form design of product image using grey relational analysis and neural network models

Hsin-Hsi Lai[a], Yang-Cheng Lin[a], Chung-Hsing Yeh[b,*]

[a] *Department of Industrial Design, National Cheng Kung University, Tainan, 701, Taiwan, ROC*
[b] *School of Business Systems, Monash University, Clayton, Victoria, 3800, Australia*

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Abstract

This paper presents a new approach to determining the best design combination of product form elements for matching a given product image represented by a word pair. A grey relational analysis (GRA) model is used to examine the relationship between product form elements and product image, thus identifying the most influential elements of product form for a given product image. A grey prediction (GP) model and a neural network (NN) model are used individually and in conjunction with the GRA model, in order to predict and suggest the best form design combination. An experimental study on the form design of mobile phones is conducted to evaluate the performance of these models. Based on expert surveys, the concept of Kansei Engineering is used to extract and evaluate the experimental samples, and a morphological analysis is used to extract form elements from these sample mobile phones. The evaluation result shows that all the NN-based models outperform the GP-based models, suggesting that the NN model should be used to help product designers determine the best combination of form elements for achieving a desirable product image. The GRA model can be incorporated into the NN model to help designers focus on the most influential elements in form design of mobile phones.

Keywords: Product form; Product image; Neural networks; Kansei Engineering; Grey relational analysis; Grey prediction

1. Introduction

The image of a product plays an important role in consumers' preference and choice of the product [1]. Whether consumers choose a product depends largely on their perception of the product image [2]. Based on the relationship between the product form and the product image perceived

* Corresponding author. Tel.: +61-3-9905-5808; fax: +61-3-9905-5159.
E-mail address: chunghsing.yeh@infotech.monash.edu.au (C.-H. Yeh).

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by consumers, design support models [1,3–5] and consumer-oriented technologies [6,7] have been developed to help designers design product form for a given product image. In particular, Kansei Engineering [8] has been developed as "translating technology of a consumer's feeling (Kansei in Japanese) and image of a product into design elements". It has been applied successfully in the product design field [9–12] to explore the relationship between the feeling (perception of the product image) of the consumers and the design elements of the product.

In this paper, we present a new approach for answering specific research questions in product design with respect to product form and product image, using the grey system [13] and neural network (NN) [14] techniques. These research questions include (a) how the product form elements affect a particular image of the product, (b) how the product form elements can be best combined to match a desirable product image, and (c) what technique should be used to help product designers determine the best combination of product form elements for a given product image. To illustrate how the approach can answer these questions, we conduct an experimental study on mobile phones for their popularity as a consumer product and their wide variety of product form elements.

In subsequent sections, we first describe how Kansei Engineering and morphological analysis can be used to extract representative samples and form elements of mobile phones as numerical data sets required for analysis. We then present the techniques used to analyze the experimental data sets for answering the research questions, and discuss the results of applying these techniques. Finally, we evaluate the performance of these techniques in order to determine the best model that can be used to help design form elements for matching a designated product image.

2. Extracting and evaluating experimental samples using Kansei Engineering

Kansei Engineering is a process of linking the consumer's feeling (Kansei) of a product, represented by an image word pair, to the product design elements, using a survey or an experiment [8]. In this paper, we conduct an experimental study using the concept of Kansei Engineering to collect numerical data about the relationship between an image word pair and form elements of mobile phones. The subjects of the experiment consist of three groups of product design experts. The first group has eight males and seven females for extracting the representative samples of mobile phones. The second group has two males and three females for performing the morphological analysis to extract form elements of mobile phones. The third group has eight males and seven females for evaluating the product image of experimental samples, whose result is used as a basis for evaluating the performance of the models developed in this study.

2.1. Extracting representative samples of mobile phones

To facilitate the identification of commonly used form elements of mobile phones in the market, we need to first classify mobile phones based on their similarity degree. This classification result can then be used to extract sample mobile phones for identifying common form elements and for subsequent model building and testing. This procedure involves the following nine steps:

Step 1: Select 54 mobile phones of various makers and models, including 30 mobile phones used in our previous study [12,15] and 24 mobile phones entering the market during 2000–2001.