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Single users' affective responses models for product form design

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ABSTRACT

This paper presents a neural network based approach to modeling consumers' affective responses for product form design. A theoretical framework for a single user's perception is developed. On the basis of this theoretical framework, a mathematical model which enables single users' responses to different products to be predicted was developed. The results obtained show that the mathematical models developed achieved highly accurate predictions.

For the purpose of obtaining a global model various individual mathematical models were created, which were based on the opinions of users representing different groups of opinion. The results suggest that, under some conditions, the combined use of various models of individual users can perform as well as a single model generated on the basis of mean market responses.

1. Introduction

The importance of the ability of a product to evoke emotions in the observer is becoming increasingly more important, since it has a decisive influence on purchasing decisions (Chuang and Ma, 2001; Desmet, 2003; Holbrook, 1985). In the current market a great variety of products of the same type can be acquired to sufficiently meet users' needs. Therefore, a product's shape, aesthetic features, visual appearance and ability to convey to the user the objectives for which it was designed, are all key to the success or failure of a product (Bloch, 1995; Chuang et al., 2001; Crilly et al., 2004). Additionally, sales platforms such as the Internet limit the user-product relationship to visual interaction alone, meaning that it is the appearance of a product which defines the image the user has of it (Dahan and Srinivasan, 2000; Vriens et al., 1998). This justifies the efforts carried out by many authors to provide models which match the attributes of a product to the consumers' affective responses (hereinafter CAR models). These models can be used to estimate how a user will assess a product in the early stages of the design process. A product's design can then be adapted to evoke the desired emotional response prior to its launch.

Hasdoğ;an (1996) studied the different types of user models and their role in product design. In some cases, such as Kansei engineering (Nagamachi and Imada, 1995), authors have aimed to translate the users' feelings into design attributes (Chang, 2008; Huang et al., 2012; Nagamachi, 2002; Schütte, 2002; Wang, 2014). Generally, the relationships obtained using these techniques are difficult to interpret, and do not enable functional models to be obtained which manage to predict the users' responses to certain design attributes (Han et al., 2000). For this reason, other approaches have been taken based on establishing conceptual frameworks of the customer's perception process in order to subsequently obtain mathematical models based on these frameworks. In other words, theoretical frameworks are created which define the mental processes shaping the users' image of the product, how judgments are formed with respect to products, and which external factors are influential. Once this conceptual framework has been defined, a mathematical model is obtained to model these processes.

Han and Hong, 2003 contends that the user's affective response is based on a cause-effect relationship with the attributes of the product. In other words, certain product attributes lead to a certain user response. This is a basic assumption for the development of a CAR model, given that the model can be created by systematically analyzing the relationship between the users' responses and products' attributes (Hsiao and Chen, 2006; Yang and Shieh, 2010). Nevertheless, establishing such relationships is not easy given that there are several fundamental problems which must first be solved. The first problem is that the mental process carried out by the user from the time he receives the information regarding the product until the time he makes a judgment on it, is in practice, unknown. It is akin to a black box relating to which only the inputs and outputs are known. Only assumptions can be made about what happens inside the box. Therefore, the conceptual framework on which the

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CAR model is based is only validated, a posteriori, if the resulting mathematical model functions accurately. The processes that take place until the users make a judgment and the factors that affect the decisions taken vary from one model to another (Crilly et al., 2004; Engel et al., 1995; Han and Hong, 2003; Han et al., 2001). In order to partially solve this problem, methods which try to determine the user response without verbal assessment have been proposed (Ho and Lu, 2014; Lu and Petiot, 2014).

The second problem relates to how to codify the inputs and outputs of the black box model, in other words, how to define the product so that it serves as a model input, and how to define and measure the user's response. The product design should be transformed into a set of meaningful and measurable specifications. Therefore, it is necessary to determine which and how many product attributes define it completely, which of the attributes is relevant for the purpose of evoking an emotional response from the user, and how to measure them. Additionally, the relationship between the products' attributes and the users' judgment is not of a linear nature where there are strong correlations between the attributes. Therefore, it is difficult to process such information in order to generate a model (Park and Han, 2004; Shimizu and Jindo, 1995; Yang and Shieh, 2010).

Another fundamental problem relates to determining the mathematical technique whose use is most appropriate for obtaining the model. This problem has been approached from different angles. Traditional market response models are based on statistical techniques such as the multiple linear regression technique, logistic decline, discriminant analysis, etc. Nevertheless, more recent approaches tend to rely on techniques which are more flexible such as the Artificial Neural Networks (ANNs), or semi-parametric regression models, fundamentally due to their ability to find the non-lineal relationships which exist between variables. ANNs are used in numerous marketing and product design fields like market response prediction, segmentation or consumer choice prediction. Various studies have been carried out to compare the results obtained using statistical and ANN response models (Dasgupta et al., 1994; Paliwal and Kumar, 2009; Venugopal and Baets, 1994; West et al., 1997). In these studies, the capacity of models based on ANNs outperforms that of models based on statistical methods. This occurs, for example, in ten of the twelve comparative studies analyzed (Paliwal and Kumar, 2009). Consequently, most of the recent research in this field tends to rely on ANNs (Chen et al., 2002; Ishihara et al., 1997; Lai et al., 2006, 2005; M. Shieh et al., 2008; M. D. Shieh et al., 2008; Yang and Shieh, 2010).

However, the fundamental problem relating to the development of a CAR models stems from the variety of different users' opinions regarding a single product. Generally, conceptual frameworks are based on the premise that there is a cause and effect relationship between the attributes of the product and the user's response. Nevertheless, these relationships vary from one user to the next since their opinions are not based entirely on the attributes of the object. Individual and external conditioning factors such as personal taste, cultural environment, level of education, and personal motivations and aims will all lead the perception of each user to vary (Allenby and Ginter, 1995; Chai et al., 2015; Engel et al., 1995; Hoch et al., 1995). However, this does not mean that the existence of a cause and effect relationship between the product's features and the user's response should be ruled out. These conditioning environmental factors should simply be considered as characteristics of the user himself. To take the above into account, conceptual frameworks consider the user in addition to personal and environmental conditioning factors. However, the mathematical models developed based on these frameworks do not usually reflect this approach. For example, mathematical models tend to look for relationships between product attributes and the mean responses of a representative sample of users. It can be said that these models attempt to predict the opinion of an average user. Although it can be concluded that there is a causal relationship between the appearance of an object and the consumers' mean responses, these relationships are much more complex than the relationships for the opinion of a single user. In the sample of users taken into account for the development of the model, a user whose opinions regarding a product are similar in all cases to the mean market responses might be impossible to find. Average opinion consists of the result of the judgment of users whose ways of perceiving product attributes might be different and whose way of assessing them are definitely different. Consequently, these CAR models do not correspond to the conceptual framework on which they are based.

The development of these models requires a lot of effort and survey time. Many users and many responses by user are necessary to generate the data to obtain the statistical models. This could be a big problem because respondents' boredom and fatigue could lead to obtain unreliable data. This study shows a different approach to generate a CAR model that looks for reducing the amount of time and effort to obtain a market model and considers the previously exposed problems in the development. For this, a conceptual framework of the user perception process was first proposed. This theoretical framework took into consideration the personal and environmental factors conditioning the judgments made by each user. Therefore, in practice the CAR model obtained based on this framework would only be valid for one user. However, although the perceptual relationships to be modeled are different for different users, if the opinions of a group of users regarding a selected sample of products are similar enough, it can be concluded that their perception processes and specific conditioning factors are similar. Consequently, by grouping users based on the similarity of their judgments, a mathematical model can be generated for a user representative of each one of those groups. With a certain margin of error, the CAR model would be valid for all users included in this cluster. As opposed to the traditional approach, in which a model predicting the mean response of the users in the cluster would be created, a model based on the opinions of a user representative of the cluster was generated. A model created in this way takes into consideration the individual conditioning factor affecting the way in which the product is perceived. By generating a model for each group of users with similar opinions, the mean market response was able to be determined. For this purpose, the response from each model was weighted by the relative size of the cluster containing the user from which the model was obtained.

The question posed in this study was whether a model based on opinions of individual users who are representative of various groups of users could be exact enough to avoid the development of a more time consuming model based on the mean opinion of all users. Additionally, the model based on this new approach was tested to determine if it reached a high enough degree of generalization enabling it to be used to predict different judgment of users on different types of products.

For this purpose, the paper was structured as follows: the first section briefly describes the conceptual framework of the product perception process which was created in this study as a basis for the CA model. The second section briefly explains the way ANNs and Genetic Algorithms (GAS) operate, being that they were used to develop the mathematical model. The final section describes the mathematical model developed and how it was applied to two case studies, in addition to the results and conclusions made.

2. Proposed conceptual framework

Industrial products possess a number of attributes which are