Telematics and Informatics xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Telematics and Informatics

journal homepage: www.elsevier.com/locate/tele

An integrated-mental brainwave system for analyses and judgments of consumer preference

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ARTICLE INFO

Article history:
Received 1 September 2016
Received in revised form 3 November 2016
Accepted 3 November 2016
Available online xxxx

Keywords:
Brainwaves
Electroencephalography (EEG)
Product appearance
Consumer preference
Mental tasks

ABSTRACT

With the competition expansion of consumer markets, product appearance becomes important topics when the products, which consumers make decisions to select, have similar quality and content. Hence, enterprises and companies spend a lot of time and money, and pay more attention to enhance product appearances to further attract other consumers. In comparison with using only questionnaires, obtaining consumers' thoughts directly from their brains can accurately grasp their actual preference. Undoubtedly, it can provide effective and precious decisions for enterprises and companies. In this study, consumers' brainwaves integrated with mental tasks are extracted through a wearable, portable, wireless electroencephalography (EEG) device. The extracted EEG data are then trained using perceptron learning to make the judgments of integrated mental works well for each subject. They are then applied to the analyses and judgments of consumer preference. Finally, questionnaires are also used as the references on the training process. They are combined with brainwaves data to create a prediction model that can significantly improve accuracy. The partial least squares are used to compare the correlation between different factors in the model and ensure the test can accurately meet consumers' thoughts.

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1. Introduction

It is a key factor to make products stand out in the market and catch the attention of consumers for increasing profits and creating a storm that sweeps the consumer market. There is a recognition that product design is emerging as a key marketing element (Dawar and Chattopadhyay, 2002; Luo and Tung, 2007; Noble and Kumar, 2010). The visual appearance of a product plays a significant role in determining responses of consumers (Crilly et al., 2004) and is recognized as an opportunity to create a differential advantage in the marketplace (Creusen and Schoormans, 2005).

Many factors affect consumer selections before purchasing. The various aspects of product design play a vital role in the interaction between consumer and product, thereby potentially affecting consumer preference (Hoyer et al., 2010; Kumar et al., 2010). Indeed, consumer preference can be affected during the buying process by the appearance of packaging. Therefore, packaging is crucial because it can create an emotional attachment in the minds of consumers from the very first glance (Harith et al., 2014). Generally, enterprises will use questionnaires or telephone surveys to investigate consumer preference, and then combine this with sales data to help managers make strategies. There is a difference, however, between interview responses and actual buying actions because the emotion during an interview may be different from looking at the physical

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http://dx.doi.org/10.1016/j.tele.2016.11.002
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Please cite this article in press as: Hsu, W.-Y. An integrated-mental brainwave system for analyses and judgments of consumer preference. Telemat. Informat. (2016), http://dx.doi.org/10.1016/j.tele.2016.11.002

product. Invalid or bad results from a questionnaire can lead decision makers to make the wrong decision (Ergu and Kou, 2012; Hsu, 2015c).

The goal of the study was to accurately grasp the consumer preference for product appearance. For example, when faced with different products with the same price and similar features, consumers may choose based on the appearance of the products. Sometimes consumers have difficulty making decisions by themselves. It is generally accepted that the look of a product or its package has an important effect on consumer choice at the point of purchase (Garber, 1995). In the situation where consumers are not considering price or function, product appearance plays the most important role. Garber's (1995) model emphasized the effects of product appearance on consumer attention (Creusen and Schoormans, 2005; Talke et al., 2009). This also makes it more difficult to establish a reference, because there is no way of understanding consumer preferences. In the case of unpredictable preference, it is important to know how to help companies obtain more powerful evaluation criteria for them to design and build the direction of product appearance. To achieve this goal, a system to detect brainwaves has been built to help provide a deeper analysis of consumer preference (Chen and He, 2013; Hsu, 2016b).

To efficiently and accurately understand the emotional reactions and degrees of concentration of consumers when they are making response, this system uses a brain-computer interface device to detect consumer brainwaves. It generates electroencephalogram (EEG) data to help analyze and discuss the corresponding relationships between mood swings and the replied answers (Tsai and Shih, 2013; Hsu, 2015a,b). Depending on the relationships, companies can craft different marketing strategies to make product sales achieve maximum benefits. Compared to those complex and inconvenient brainwave devices, which are time-consuming and uncomfortable to wear, the device adopted for this study can more quickly and efficiently test every subject. In addition, the system is executed on a personal computer, so it can be performed anytime, anywhere. The computer system quickly generates analysis results and provides reference data of the testing.

We focused on the use of an EEG to detect and integrate subjects' the changes of degree of mental tasks in this study. With a series of training processes, the study used incremental steps to assess consumer reactions while answering different questions and quickly analyzed the results (Hsu, 2011, 2016a). In the future, this system is expected to be used to precisely detect the preference of products from consumers and contribute the data to help companies create more appealing packaging for their products. It not only reduces the risk of releasing a new product design, but also catches consumers' eyes more precisely.

2. Theoretical background

2.1. Neurons and brainwaves

Numerous neurons communicate with each other in a human brain. The action potential generated after activation is transmitted to the synapse by means of axons (Lodish et al., 2000; Hsu, 2017). The release of neurotransmitters can cause the next neuron to generate postsynaptic potentials, which further stimulate the neuron to generate action potentials. Brainwave intensity under normal circumstances is less than 100 μV, usually just dozens of μV, and the frequency ranges between 0.1 Hz and 40 Hz. It can be applied to the detection of depth of sleep, mental status, mentation, and etc.

2.2. EEG signals

Generally speaking, the electrodes with invasive approach are popular in common applications. EEG device is typically used a non-invasive method to record electrical activities of the brain along the scalp. EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain (Hsu, 2012). In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activities over a period of time, as recorded from multiple electrodes placed on the scalp. Diagnostic applications generally focus on the spectral content of EEG, that is, the type of neural oscillations that can be observed in EEG signals (Nicolas-Alonso and Gomez-Gil, 2012; Hsu, 2014).

In this study, the Emotiv EPOC device is used for the experiments. The Emotiv EPOC is a high resolution, neuro-signal acquisition, processing wireless headset that monitors 16 channels of EEG data. EPOC internally samples at a frequency of 2048 Hz, which is then down-sampled to 128 Hz sampling frequency per channel, and sends the data to a computer via Bluetooth. It uses a proprietary USB dongle to communicate using the 2.4 GHz band. Prior to use, all felt pads on top of the sensors must be moistened with a saline solution.

Moreover, the Emotiv Software Development Kit provides a packet count functionality to ensure that no data is lost, a writable marker trace to ease single trial segmentation tasks, and a real-time sensor contact display to ensure quality of measurements. The effectiveness of the EPOC headset as a real-time brain EEG scanner was demonstrated in a number of recent publications (Khushaba et al., 2013).

2.3. Machine learning with perceptron

The perceptron learning (PL) was first proposed by Frank Rosenblatt (Rosenblatt, 1957). It is a machine-learning-based approach, which classifies data into two categories (Hawkins et al., 2013). PL initializes the weight to a random number and then determines an input that represents numbers into the corresponding group by means of the function

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