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A Personal Book Recommendation System Based on Brainwave Analysis

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(Poster)

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ABSTRACT

The recommendation system collects and analyzes users' preferences, and recommend information or commodities to users automatically. In this research, we developed an online book recommendation system based on users' brainwave information. We collected users' brainwave information by electroencephalography (EEG) device, and applied empirical mode decomposition (EMD) to decompose the brainwave signal into intrinsic mode functions (IMFs). A back-propagation neural networks (BPNN) model was developed to portrait the user's brainwave-preference correlations based on IMFs of brainwave signals, and it was applied to design and develop the recommendation system. This research has highlighted a research direction about human computer interaction (HCI) design about recommendation system.

Keywords

Recommendation system, brainwave, empirical mode decomposition (EMD), neural network.

RESEARCH BACKGROUND AND MOTIVATION

With the rapid development of the Internet and digital technologies, traditional methods of producing and communicating knowledge and information have changed. As the Internet is not limited by time or place, it has become a major source from which people obtain and spread information. Moreover, the Internet facilitates the creation of information in such a large number that it allows users to quickly browse and use. However, such a massive amount of information is likely to cause user difficulty in understanding information, also known as information overload, which is defined as the cognitive burden of users caused by the amount of information, leading to difficulties in understanding meaning and effectively making decisions. In an era of such information explosion, information overload frequently occurs, preventing people from obtaining valuable information.

Information filtering and information extraction are gradually emphasized to help users retrieve useful information from the huge amount of information. Various types of recommendation systems are developed to help users effectively obtain key information.

A recommendation system is defined as an information system that can recommend related information or products for users according to their preference, purchasing behavior, entered keywords, or browsing history on the Internet. Nowadays, a recommendation system can be applied to any information (Park et al., 2012); for example, Castro-Schez et al. (2011) introduced the concept of fuzzy logic in B2C e-commerce, which allows the system to provide the search results of products that are potentially related, even when the keywords are not accurate; Barragáns-Martínez et al. (2010) introduced recommendation systems for Web 2.0 TV programs, which provide recommendations according to a combination of content-oriented filtering and collaborative filtering, as well as the typical advantages of social networking, such as supporting communication between users, allowing users to add and tag content, evaluations, review items, etc. In contemporary society, the rapid development of new technology and the Internet facilitate the acquisition of information, and render the process more simple and convenient. Crespo et al. (2011) attempted to build a recommendation system based on the known preferences of other users or other users with similar characteristics. Regarding mobile music, the traditional collaborative filtering system, which collects data according to the preference of users' ratings, is rather limited. Many users find it difficult to directly express their preferences when they are not used to the interface and high data costs. Lee et al. (2010) put forward a more suitable method called implicit rating, which is based on collaborative filtering for the mobile music market. The experimental results show that this new method has better accuracy than the traditional method. Some famous e-commerce sites or video websites, such as Amazon.com, eBay, Reel.com, and YouTube, have introduced recommendation technology for users' reference (Schafer et al., 1999; Davidson et al., 2010; Ricci et al., 2011).

According to the adopted information filtering technologies, recommendation systems can be divided into content-oriented filtering, collaborative filtering, demographic filtering (Pazzani, 1999), and hybrid filtering (Adomavicius and Tuzhilin, 2011). Content-oriented filtering constructs a model of a user's preference by integrating their historical records, such as shared contents and reviews, before comparing the similarities between the products and the user's preference. The product with the highest similarity will be recommended to the user. Collaborative filtering is based on the preferences of a group of similar users and makes recommendations to a single user according to group preferences. Hybrid filtering merges content-oriented filtering and collaborative filtering, with indicators of weight, exchange, and mixture (Burke, 2002).

Regardless of which method is adopted, users' preferences must be recorded before setting up the preference model to provide recommendations. Users' preference can be recorded in many ways, such as entered keywords, browsing history, purchase records, questionnaires, and product reviews. The mechanism of collecting information regarding users' preference is the key issue in designing a recommendation system.

However, with the advances of human sensor technology, we can easily measure users' physical conditions via such equipment, as such devices will display data that reflects the user's physiological and psychological status to obtain the overall picture of the situation, which is helpful for the establishment of the user's preference model. Lin et al. (2007) utilized different types of music to produce four kinds of emotions, including happiness, anger, sadness, and joy, which were signaled by brainwaves to indicate the subjects' psychological reaction at that time.

Due to the advancements in sensing technology for brain signals, neuroscience, and information systems, a new discipline has been developed that combines the above fields into a neuro-information-system (NeuroIS) (Dimoka et al., 2007; 2012), which has become an emerging research field and received much attention of scholars. Scholars of information systems and neuroscience have tried a variety of non-invasive devices to measure brain activity. The currently applied devices include magnetoencephalography (MEG), electroencephalography (EEG), functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and eye fixation related potentials (EFRP) (Dimoka et al., 2012).

At present, a single channel head-mounted EEG has been launched on the market, which is widely available at a reasonable price, comfortable to wear, and user-friendly. In particular, as its weight is low, it allows users to be free from perceiving the experiment during the experiment (Kim et al., 2012).

However, as brainwave signals are nonlinear, subsequent research on the treatment of brainwave signals is necessary. The empirical mode decomposition (EMD), as proposed by Academician Huang et al. from Academia Sinica in Taiwan (Huang et al., 1998), can specifically process non-linear and unstable brainwave signals. Therefore, this study adopts EMD to process the non-linear issue of brainwave signals.

In previous studies of brainwave signals, many scholars used artificial neural networks in machine learning to classify brainwave signals to detect whether a driver was struck by drowsiness or epilepsy, and the classification results were great (Belakhdar et al., 2016; Djemili et al., 2016; Hassan and Subasi, 2017). Therefore, this study adopts artificial neural networks to classify brainwave signals.

RESEARCH OBJECTIVE

Previously, recommendation systems were designed based on the external behavior of users or other users with similar preferences; however, neither of these systems considered the users' psychological status. Consequently, we attempt to construct a recommendation system based on the brainwave-preference correlational model, which is developed by applying the users' brainwave signals as their preference indicators. The brainwave signals are analyzed by EMD first, and brainwave-preference correlational model is developed by neural network. In this study, books are selected as the commodities for recommendation. We developed a recommendation system to predict the users' preferences by analyzing their brainwave signals, and provide recommendations to the users.

SYSTEM ARCHITECTURE

To develop the recommendation system, two stages experiment should be conducted for training recommendation model and providing recommendation sequentially. The first stage experiment includes recording the subjects' review scores for books while collecting the current brainwave signals, transforming the brainwave signals via EMD, training the system by an artificial neural network for emotional classification of the brainwave signals, and establishing a personal brainwave-preference correlational model. The second stage includes developing a personal book recommendation system based on the brainwave-preference correlational model developed in the first stage, to predict the subjects' preferences, recommending books for their reference. The system architecture is shown in Figure 1.

The main purpose of the first stage is to establish the relationship between the brainwave signals and the subjects' preferences, thus, an online bookstore is developed for this experiment. While wearing the EEG device on their heads, the subjects are invited to browse the website; and then asked to grade the books according to their preferences; the system records the books viewed

by the subjects, their preference scores, and the collected brainwave signals. The brainwave signals are processed by EMD for the acquisition of IMF, where four indicators in each section of IMF include maximum, minimum, average, and standard deviation, which are the input parameters and the preference scores are the output parameters of the artificial neural network, in order to establish the brainwave-preference correlational model.

The first stage is designed to establish the brainwave-preference correlational model, which is the core model of the recommendation system in the second stage. We developed an online bookstore for subjects to browse during the experiment. The main purpose of the website is to record the book types and browsing time of the subjects. In addition, this study establishes a module of book preferences, where three items, "like", "common" and "dislike", are set to indicate the scale of the subjects' preferences for the books, and the subjects scored their preferences after reading them.

We also recorded the subjects' brainwave signals with MindWave, as developed by NeuroSky; the equipment is a portable electroencephalograph, and its data are transmitted to the computer via Bluetooth. The data captured during the experiment includes the original brainwave signals, the degrees of concentration and meditation according to the eSense indicators developed by NeuroSky, as well as alpha, beta, Delta, theta, and gamma. This study records the original brainwave signals as the experimental data.

EMD module

Brainwaves are nonlinear, and because EMD can process nonlinear and unstable wave signals, meaning it can convert any unstable and nonlinear signals into IMFs (Djemili et al., 2016). We adopt the EMD method to preprocess the brainwave signals. Then, four IMFs statistical values: minimum, maximum, average, and standard deviation, are input as eigenvalues (Djemili et al., 2016) to the artificial neural networks for training and to establish the brainwave-preference correlational model.

Neural Network Module

The artificial neural networks used by this study is back-propagation neural networks (BPNN). The main purpose is to input the subjects' preferences, as well as the four statistical values from IMFs after EMD conversion of the brainwave signals, into the neural network for training and developing the brainwave-preference correlational model. In the second stage, the trained brainwave-preference correlational model can used to predict the subjects' preferences and make book recommendations.

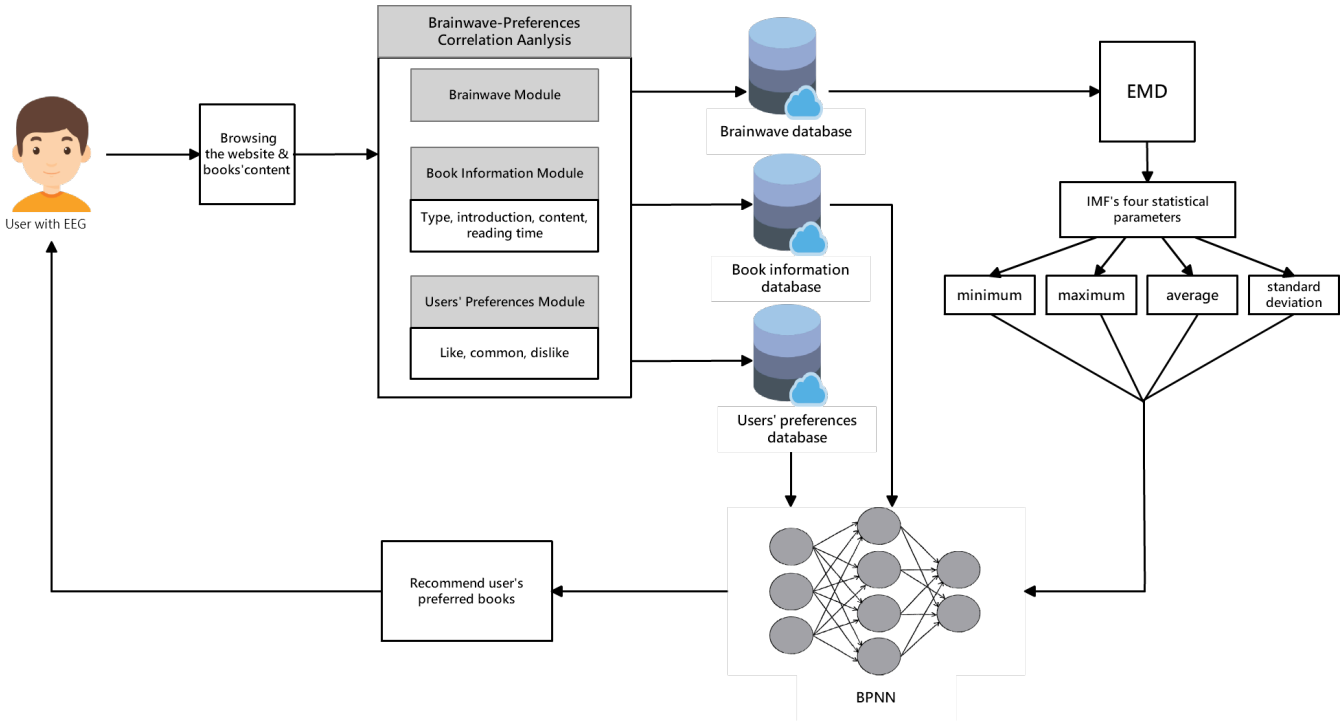

Figure 1. A Books Recommendation System based on Brainwave Analysis

CONCLUSION

We have developed a recommendation system based on brainwave analysis in this research. The brainwave signal was applied to indicate the personal preferences, processed by EMD first and analyzed by BPNN to conduct the brainwave-preference correlational model. The model can be used as the core of the recommendation system. We have highlighted a novel HCI research direction about brainwave based recommendation system. The experimental system has been developed, and we are now conducting some experiments to collect the empirical data to evaluate the recommendation accuracy of the proposed recommendation system.

Due to the instability of brainwave signals, we also found that it is difficult to get stable and consistent results in our preliminary experiment. It needs more efforts to gain more stable and reliable brainwave signals analysis in the future.

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