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Recommender system architecture for adaptive green marketing

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ABSTRACT

Green marketing has become an important method for companies to remain profitable and competitive as the public and governments are more concerned about environmental issues. However, most online shopping environments do not consider product greenness in their recommender systems or other shopping tools. This paper aims to propose the use of recommender systems to aid the green shopping process and to promote green consumerism basing upon the benefits of recommender systems and a compliance technique called foot-in-the-door (FITD). In this study, the architecture of a recommender system for green consumer electronics is proposed. Customers' decision making process is modeled with an adaptive fuzzy inference system in which the input variables are the degrees of price, feature, and greenness and output variables are the estimated rating data. The architecture has three types of recommendation: information filtering, candidate expansion, and crowd recommendation. Ad hoc customization can be applied to tune the recommendation results. The findings are reported in two parts. The first part describes the potentials of using recommender systems in green marketing and the promotion of green consumerism; the second part describes the proposed recommender system architecture using green consumer electronics as the context. Discussion of the proposed architecture and comparison with other systems are also included in this part. The proposed architecture provides a capable platform for personalized green marketing by offering customers shopping advices tailored to their preferences and for the promotion of green consumerism.

1. Introduction

Recommender systems have become an important technology for electronic commerce on many fronts (Bose, 2009; Kauffman & Walden, 2001). It can filter for online shoppers the vast amount of information, saving the customers from the information overload problem (Chen, Shang, & Kao, 2009). It can be a decision aid for customers who are challenged when they are in the market for unfamiliar products. It can be a strategic marketing platform on which online venders can personalize promotions and sales for each customer (Chen, 2008; Shih, Chiu, Hsu, & Lin, 2002). Recommender systems have been vigorously researched and developed in the fields of academia and business. Some notable examples include Apple Inc.'s Genius of iTunes that make music recommendations, University of Minnesota's MovieLens and Netflix's Cinematch that recommend movie titles, Amazon.com's recommender system that generates recommendations of an assortment of products, and Outbrain.com's blog rating widget that recommends blogs a rater might be interested in. The domain of recommender systems is not limited to the famous instances mentioned above. Recommender systems for news, web pages, jokes, academic articles, consumer electronics, restaurants, and a plethora of other subject matters, have been researched and implemented (Adomavicius & Tuzhilin, 2005; Iijima & Ho, 2007). However, to our knowledge, few researches have dealt with recommender system of green product.

Green product is increasingly important in our global village as the general public is becoming more concerned of our impact on the planet. Driven by this trend, companies have been trying to design and manufacture greener products, and have been trying to promote their products and brand images by communicating their greenness to the customers via a variety of channels. Yet, eco-labeling remains one of the fundamental ways to inform the customers how green their products are and in what respect their products are green. Eco-labels, usually issued by third-party organizations, are textual or graphical presentations of the environmental characteristics of a product, which can be found on the product itself, on the packaging, or in the manual. Examples of eco-labels include Green Seal, Energy Star, and WEEE (Waste Electrical and Electronic Equipment Directive). Studies have shown that public education campaign is one of the key determinants of

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successful eco-labeling programs (Malcohn, Paulos, Stoeckle, & Wang, 1994).

Public education campaign of eco-labeling programs can be done via methods such as media coverage, regulation, promotion, school curriculum, and so on. This research proposes using recommender systems, in addition to these methods, as a means to educate and inform on-line customers. The justification of such proposal relies on two of the primary functions of a recommender system: information filtering and candidate expansion. When customers are confronted with a flood of products or with unfamiliar products, they may have difficulty in making a shopping decision. Based upon what they have purchased before, a recommender system can help the customers by filtering out items that are unlikely to be preferred. For example, Amazon.com's recommender system generates a personalized list of recommended products each time a customer visits their web site. As to candidate expansion, when a customer is evaluating the decision to buy a product, a recommender system can ensure that other good candidates are included in the consideration set by finding related products based upon the product under consideration. Take Amazon.com's recommender system for example again. When a customer is looking at the catalog page of a product, the recommender system recommends items similar to the current item. Tapping into the capabilities of information filtering and candidate expansion, recommender systems can be transformed into a green product advocate informing the customers of available choices that are greener. A recommender system of green products can also sieve through a set of products to retrieve only the items matching an implicitly or explicitly degree of greenness designated by a customer. Such system can also find other products whose greenness and other aspects are comparable based upon a product under consideration. The reduced effort in the decision making process may enhance the quality and users' satisfaction of the decision (Häubl & Trifts, 2000), which in turn will make green shopping a more enjoyable experience.

The adaptability of a recommender system can also contribute to the promotion of green consumerism by using a technique called foot-in-the-door (FITD) technique (Freedman & Fraser, 1966). FITD is a compliance technique in which a person is more likely to accept a larger request if this request is preceded by a smaller request. The technique is also found to be effective in computer-mediated communication (CMC) in addition to face-to-face or telephone communications (Guéguen, 2002). In a recommender system of green products, items with higher degree of greenness and with comparable or equal degrees of price and feature can be first recommended to a user who is reluctant to buy green products. Appropriate feedback should be given to the user about the environmental contribution of the purchase one has made. The degree of greenness of the recommended items in the future can be adjusted accordingly if the users' purchasing transactions reflect acceptance or rejection of the items.

The goal of this paper is to develop a recommender system architecture for green consumer electronics. Instead of simply adding an additional *green* attribute to the conventional recommender systems, the architecture uses an adaptive behavioral agent to find the products of a certain degree of greenness according to users' behaviors. The agent uses an adaptive fuzzy inference system to learn users' behavior over time with a basic assumption that a bilateral relationship of either symbiosis or antibiosis exists between the pairs of price vs. feature, price vs. greenness, and feature vs. greenness.

The rest of this paper is organized as follows. The next section gives brief review of recommender systems and fuzzy inference systems. The proposed architecture is presented and discussed in Section 3. Conclusions and future research directions are presented in the final section.

2. Related work

2.1. Recommender system

Recommender systems have a variety of forms with different functions (Manouselis & Costopoulou, 2007; Wan, Menon, & Ramaprasad, 2007). Therefore, it warrants a clear definition of the kind of recommender systems this paper is dealing with. Schein, Popescul, Ungar, and Pennock (2005) define recommender systems as the following: "Recommender systems suggest items of interest to users based on their explicit and implicit preferences, the preferences of other users, and user and item attributes". This definition points out the fundamental parts and necessary input and output data of a recommender system. First, a recommender system needs data of preferences from single user or multiple users. The system can explicitly elicit preferences from users by asking them to rate some items, or implicitly by inferring their preferences from past transactions (Resnick & Varian, 1997). Second, a recommender system requires attributes of users and items. Manouselis and Costopoulou (2007) refer to these two sets of attributes as "user model" and "domain model", respectively. Several representations can be used as user models, such as per user product ratings, demographic attributes, transaction histories, and so on. On the other hand, domain models can be represented as characteristics of products and as derived attributes such as taxonomies, hierarchies, and ontologies. Both models may utilize the acquired user preferences to derive their own data.

The core of a recommender system is the mechanism of suggestion generation based upon the user model and domain model. The mechanism can be formulated as follows (Adomavicius & Tuzhilin, 2005): Let C be the set of all customers and P be the set of all products that a recommender knows of. In addition, let $U(c, p)$ be the utility function that associates (c, p) pairs with utility values which can be ratings, profits, or some other measurements. The objective of a recommender system is to find a set of items $p' \in P$ such that $U(c, p)$ is maximized for a customer. The mathematical formulation is as follows:

$$\forall c \in C, \quad p' = \arg\max_{p \in P} U(c, p)$$

In the formulation, "arg max" means "the argument of the maximum".

Recommender systems can be generally classified into three categories according to the mechanism of recommendation generation (Adomavicius & Tuzhilin, 2005; Schein et al., 2005): (1) Content-based systems recommend items that are similar to the ones a user preferred in the past. (2) Collaborative systems recommend items that other like-minded users preferred in the past. (3) Hybrid systems recommend items by combining content-based and collaborative methods in recommendation generation.

As Adomavicius and Tuzhilin (2005) point out, content-based and collaborative systems have some challenges to be dealt with. For content-based systems, the first problem is "limited content analysis", in which case the recommendation is limited by the features associated with the items. However, some features are harder to extract than others are. For example, extracting features from textual information is easier than from multimedia data. Also, items that are identical in terms of features are indistinguishable. The second problem is overspecialization, in which case the system can only recommend items that are similar to items a user liked in the past. In other words, the lack of diversity may jeopardize the practicality of a recommender system. The third problem is "new user problem", in which case a user is unable to get reliable recommendations until a sufficient amount of transactions are present for the recommender system to learn about the users' preferences.