Combining empirical experimentation and modeling techniques: A design research approach for personalized mobile advertising applications

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Abstract

We propose a design research approach combining behaviour and engineering techniques to better support user modeling in personalized mobile advertising applications. User modeling is a practical means of enabling personalization; one important method to construct user models is that of Bayesian networks. To identify the Bayesian network structure variables and the prior probabilities, empirical experimentation is adopted and context, content, and user preferences are the salient variables. User data collected from the survey are used to set the prior probabilities for the Bayesian network. Experimental evaluation of the system shows it is effective in improving user attitude toward mobile advertising.
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1. Introduction

With the development of wireless and mobile networks, mobile commerce (m-commerce) is creating significant benefits and new business opportunities for both mobile devices and services. According to *Research and Markets* [63], the number of mobile users worldwide is expected to climb to 2 billion by 2007, and the annual handset sales are predicted to generate more than U.S. $3 billion by 2009. The high penetration rate of mobile phones has resulted in the increasing use of handheld devices to deliver advertisements of products and services. Mobile advertising revenues, as indicated by many research firms, make up the largest share of m-commerce revenues. One may expect mobile advertising to be even more appealing to consumers who use location-sensitive and time-critical m-commerce applications.

However, constraints in using both mobile networks and devices impose significant negative influences on the operational performance of m-commerce applications. For example, the small screens of the devices allow the user to view only limited pages of information [39]. Many other inherent constraints exist in a mobile computing environment (e.g., minimal battery power on wireless devices [71], limited and error-prone wireless links [5,47],

limited input and output capacity [51], the diversity of devices, and the myriad differences in user profiles), which should be taken into consideration in the design and development phases of m-commerce services and applications [4]. The success of m-commerce largely depends on whether personalization can be well utilized to deliver highly personalized and context-sensitive (time- and location-dependent) information to mobile users. Providing personalized information to mobile users will create better customer satisfaction and will in turn increase the demand for mobile services.

The practice of randomly sending promotion messages to all available users results in user dissatisfaction and a high advertising cost for the merchants. In an effort to tackle this problem, we have developed a Bayesian-network-based mobile application prototype, which is designed to provide personalized dining advertisements to mobile users. In order to support this objective, we propose a design research approach that combines empirical experimentation and modeling techniques to help construct the user models with more realistic data support. The Bayesian network is an efficient tool for building user models of domains with inherent uncertainty [41,59], and is therefore adopted as the key modeling technique for the construction of the user model.

The reasons for choosing empirical experimentation to support the construction of the Bayesian-based user model are threefold: First, this technique verifies whether personalization is indeed an important factor that contributes to consumers' perceptions of mobile advertising. The collected data are analyzed using the Partial Least Squares (PLS). Second, this method enables the determination of what variables should be considered to strengthen the personalization capability so that merchants can focus on these variables in order to more effectively deliver personalized mobile advertisements. Third, the empirical experiment provides the data for setting prior probabilities in the Bayesian-network-based user models. After identifying the network structure variables and the prior probabilities, a Bayesian-network-based user model can be built accordingly.

To demonstrate the use of the proposed design research approach, we have constructed a prototype that is a personalized mobile advertising application consisting of two major parts: a model component and a mobile Internet connectivity system. The component is Bayesian network based and contains a user model that describes the user's profiles and preferences, a context model that describes contextual information, and a matching engine that integrates information from the two models and the content information to predict the most likely interested

customers or matched restaurants. The mobile Internet connectivity system implements the model component to provide relevant advertising information to the right customers or matched restaurants.

This paper is organized as follows: Section 2 reviews the literature on mobile advertising, consumer behaviour, personalization, Bayesian networks, and user modeling. Section 3 focuses on a research framework of the factors affecting user attitude toward mobile advertising, and the particular dimensions of personalization. Section 4 describes the methods used to collect the data in order to verify the research frameworks. Section 5 describes the elements and structure of the Bayesian-network-based model component. Section 6 presents the mobile Internet system that implements the model component to deliver the right mobile advertising to the right users at the right time and place, and helps users to find matched restaurants. Section 7 evaluates the application, and the final section highlights the contributions of this research and concludes the paper.

2. Literature review

2.1. Mobile advertising

Short message services (SMS) have become a new technological buzzword in transmitting business-to-customer messages to such wireless devices as cellular telephones, pagers, and personal data assistants. Many brands and media companies include text message numbers in their advertisements to enable interested consumers to obtain more information [60]. Mobile marketing uses interactive wireless media to deliver personalized time- and location-sensitive information promoting goods, services, and ideas, "thereby generating value for all stakeholders" [26]. Mobile advertising is predicted to be an important source of revenue for mobile operators in the future [25] and has been identified as one of the most promising potential business areas [46]. Compared to traditional and Internet-based advertising, mobile advertising has distinctive features such as personalization [1,43,52,68] that can greatly enhance advertising effectiveness. For instance, in comparison with much advertising in traditional media, mobile advertisements can be customized to better suit a consumer's needs and improve client relationship [32]. Examples of mobile advertising methods include mobile banners, alerts, and proximity-triggered advertisements [34].

A mobile advertising study with 1000 mobile phone users, initiated by Barwise and Strong [9], showed mobile advertising generated high levels of readership