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Abstract

Along with the high proliferation of mobile phones and other mobile devices, research on the use of short messaging service（SMS）to access customers through their handheld devices has gained much attention, which is termed as mobile advertising. In order to make the best use of mobile advertising to benefit companies and customers becomes more emergent. One of the most important and successful factor that will bring more positive attitudes towards mobile advertising and induce customers to behave positively is personalization, which has been confirmed in many prior studies. Therefore, it's necessary and essential for researchers to design an effective system capable of recommending personalized mobile advertising to mobile users. The purpose of this paper is to fulfill this task. We present such a kind of personalized mobile advertising system based on Bayesian Network. Then, we brought out a thorough evaluation of our system in a laboratory environment. Experimental results showed better performance of our system in furnishing personalized mobile advertising than conventional method (random advertising).

Keywords: Bayesian Network; Personalized Mobile advertising; System Evaluation

Introduction

Along with the high proliferation of mobile phones and other mobile devices, more and more researchers have paid much attention to a new channel of marketing named mobile advertising, or wireless advertising, which refers to the transmission of advertising messages

via mobile devices such as mobile phones (Haghirian et al. 2005). Compared with traditional media and internet-based advertising for contacting the public, mobile advertising has its own advantages and challenges. Therefore every mobile ad should be personalized before they are displayed on mobile users' devices. Otherwise, from the perspective of customers, the spam of mobile ads will irritate customers, and damage the company's images in customers' mind. The company will also waste much money on delivering mobile ads to customers for their products due to the negative effects of mobile advertising. Many behavioral studies which focused on factors influencing people's attitudes toward mobile advertising found the importance of personalization on mobile advertising as well. Therefore, we designed a system based on Bayesian Network in order to achieve personalization in mobile advertising. We will introduce our system in this paper for how it is capable to do so while comparing it to other systems. After that, to be more important in this paper, we conducted a laboratory experiment to evaluate the performance of our system using some existing instruments from the behavioral study while comparing our system with random mobile advertising system (main method of delivering mobile ads nowadays). This paper is going to be structured as follows: Section 2 will give a brief introduction of our system together with some characteristic features our system has. This part focuses on the architecture and real function principles of the system. After that, Section 3, which is the most important part of this paper, starts with a thorough description of the experiment we conducted in mainland of China. Then, we will provide experimental results, and make some discussions of the performances of our system in Section 4.

Bayesian network based personalized mobile advertising system

Our aim was to develop a personalized mobile advertising system which can help merchants to find mobile users that are most likely willing to accept the advertisements matching their preference and current situation. Our personalized mobile adverting system used Bayesian networks technology to facilitate the modeling of four kinds of information (User demographic information, User preference, Context information and Content information) and implementing personalization with the support of the information. Benefiting from Bayesian networks, our personalized mobile advertising system have four features compared with other mobile advertising systems. First of all, in mobile advertising application, there are many influential factors for a particular decision (i.e., whether sending a promotion message to a customer or not), so the relation between different variables and their corresponding decisions are usually not deterministic. To solve this problem, in our system we use Bayesian networks to model this domain because Bayesian networks are probabilistic representations for uncertain relations which fit the area perfectly. Secondly, Bayesian networks can readily handle incomplete data sets. We cannot always get all the information we need in mobile environment, i.e., the problem of incomplete information exists. For example, some customers may not be willing to disclose their preferences. Our system uses Bayesian networks as the match engine to address the problem because we do not need to enter the evidences of all the nodes to propagate the Bayesian networks. Thirdly, with the support of Bayesian networks, our system facilitates the combination of prior or domain knowledge and data. In any real-world analysis, it is very important to get help from prior or domain knowledge. Our BN-based system is capable of fully making use of the power of prior knowledge which can be gained from domain experts or empirical study. Finally, Bayesian networks can learn from experiences, e.g., they can learn from a database with previous cases, and continuously adapt to changes in the domain. As a result, our Bayesian network–based application does not require all probabilities with a high accuracy from the beginning in a

mobile environment because it can utilize the feedback information from the customers to adjust the probabilities.

The proposed BN-based personalized mobile advertising system has been implemented. The system's architecture is shown in figure 1).
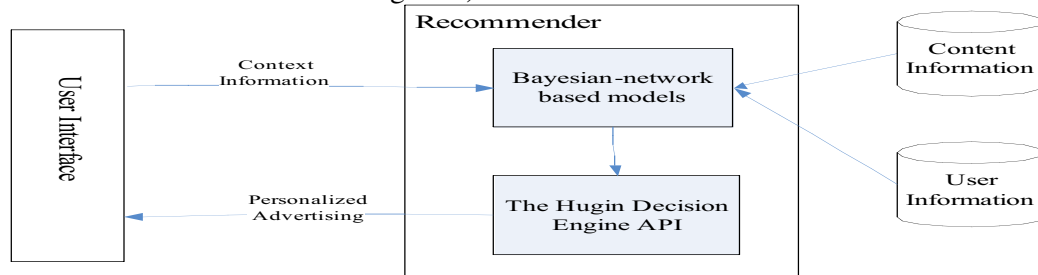
Figure 1: architecture of our system

The system consists of the user interface layer, recommender layer and database Layer. The Interface Layer includes both mobile phone interface and web interface. The database Layer includes a database storing customers' and merchants' data. The Recommender Layer, including Bayesian Network algorithm and Hugin Decision Engine API for JAVA. It is the kernel of the system which processes and implements the business logics of the system.

When a customer (mobile user) registers to our system from the interface layer, the system stores this user's demographics information and preference in the user information database. The restaurant's information is also stored when the merchant registers. For a particular restaurant, if it wants to send out promotion advertisement to customers, it can login on into the system's merchant interface and submit request. The merchant's information and the customer's information are retrieved from the database. What the system needs now is to collect the context information needed by the Bayesian Network models such as the distance specified by GPS, the system time, the weather from a weather forecast website. When the data collection is done, the states of the corresponding nodes in the Bayesian-networks are set according to these data. Using these states and the prior condition probabilities determined by the prior knowledge getting from survey data, the system will use Hugin decision engine to calculate the probability of the interest status and decide whether to send the promotion message, with support of the Bayesian-network-based models. The process results of the decision engine will be sent back to the user Interface Layer after the prediction is made. It shows the top 5 customers choices sorted by probabilities in a descending order. If the top probability of the customers exceeds the pre-assigned threshold, the system will signal "send", and then the merchant will send out the promotion message to certain users. If a user receive it and finally use it before the expiry date, this action will be considered as a positive adaptation for the system's learning purpose. Consequently, the system will learn from these experiences and update the probabilities accordingly. Besides the web interface, a mobile phone interface has also been built up for sending to and receiving information from mobile users. To conclude, every merchant can use the system to choose the potential customer targets. They will obtain a customer list sorted in a descending order according to the probabilities of consuming at their restaurants. Then they can use "push" method to send promotion messages to the potential customers more selectively.

Experimental evaluation of the performance of our system in delivering personalized mobile advertisements

Instrument development

At the beginning of starting to introduce the procedure of our experiment, it is desirable to discuss the instrument used in our experiment in order to make sure we can confidently claim our results got from our experiment were effective and convincible. Measuring the effectiveness of advertising has been a hot topic for a long time, as well as in nowadays. As Yuan and Tsao (2003) pointed out in their paper, appropriate methods of evaluating the mobile advertising effects are still in need for further investigation.

Different types of advertising should be measured in different ways, although some measures could be used for all kinds. We modified a little bit on ever validated instrument used by Tsang et al. (2004), Rogers et al. (2000) and Barwise and Strong (2002) in order to meet the specific situation of our experiment. Our instruments included four parts: personalization (whether the messages delivered by our system were more personalized than random system); attitude (whether our system would bring more positive attitude toward mobile advertising), intention (whether our system would involve in a high intention for participants to receive mobile ads using SMS) and real behavior (whether our system would bring more positive behavior than random system).

Subjects

Two hundred students were recruited as we planned from one university and one research institute in Suzhou city, Jiangsu Province of China. In order to motivate more students to participate in our experiment, each student would get a cash reward of 15 RMB and also one in ten of the participants would get a prize of 50 RMB. In fact, we conducted a survey before our experiment which would be introduced in the section of experimental procedure. Actually, we had one hundred and eighty-eight subjects participate in our experiment. This indicated that only twelve students wore out and didn't come to attend our experiment while they participated in our survey in the first step.

Experiment procedure

First step: Before we conducted our experiment in a laboratory setting, we asked each student who is willing to participate in our experiment to disclose their demographic information and their interests and preferences. Barwise and Strong (2002) also posited that obtaining explicit data from consumers, rather than leveraging existing databases, increased the messages' relevance. Every student was requested to do so in order to exclude awareness of our experimental intention for some students.

Second step: After the collection of our participants' personal information, we used these data to initiate our system, i.e., obtain prior knowledge of the Bayesian network model. Then each computer in the lab was preassigned to display one kind of mobile advertising message. The two kinds of mobile advertising were placed in alternated order. Also each student could not see the other students' computer screens next to him when he sat down because the mobile advertising messages displayed on any two neighboring computers were generated differently (personalized vs. random). After the students arrived at the lab, we let them randomly choose to sit down before one computer. Then we told them the task of our experiment was to understand their reactions when they received such a kind of food promotion message displayed on their computer. We asked each of them to put themselves under the context (containing time, location and weather) and also displayed together with the food promotion message. We employed some instruments to help them easily perceive what kind of context

they were placed in, such as location map, some important context terms written on the blackboard, and so on. The context information of each promotion message for both groups was randomly set by our system's context configuration module. At last, we asked them: "when you were under the context displayed on your computer and received a food promotion message you read on your computer, what would you do?" Then, we told them to accomplish the questionnaire exposed closely after the message. At the same time, we also explicitly claimed that no financial organization is related to our experiment and their personal information would be kept safe. Moreover, we asked them not to discuss with other students when they finished the questionnaire.

Experimental results

Table 2 Experimental Results

	Agree	Neutral	Disagree	Chi-square	p
Question 1(P/R)	43/32	18/22	23/40	6.058	<0.05
Question 2(P/R)	44/37	40/32	10/25	7.922	<0.05
Question 3(P/R)	55/50	22/22	17/22	0.644	>0.05
Question 4(P/R)	72/70	14/14	8/10	0.007	>0.05
Question 5(P/R)	18/23	12/13	64/58	0.945	>0.05
Question 6(P/R)	15/9	9/12	70/73	1.992	>0.05
Question 7(P/R)	40/34	33/22	21/38	7.585	<0.05
Question 8(P/R)	48/32	33/29	13/13	12.154	<0.05

Note: P/R stands for Personalization Group v.s Random Group

Question 1 Participants' perceptions of personalization about the message
Question 2 Participants' attitudes toward the message (whether they like it)
Question 3 Participants' willingness to receive the message
Question 4 Whether participants will read the whole message after receiving it
Question 5 Whether participants will remain the message after reading it
Question 6 Whether participants will forward the message to their friends, relatives or other persons
Question 7 Whether participants will accept the promotion and go for consumption
Question 8 Items match between participants' interests and the message
The chi-square results represent whether the samples differed in how people responded to the question. The top and bottom two boxes of the 5-point Likert-type items were collapsed into agree and disagree respectively for analysis of those questions involving statements of agreement (Schlosser, Shavitt and Kanfer 1999).

Personalization

The function of our system was to deliver personalized mobile advertising using SMS, so in the beginning we asked our participants: "whether you perceive the message put on your computer to be personalized?" As table2(Q1) shows, there is a significant difference on personalization between personalized group and random group (chi square=6.058, p<0.05). In addition, more participants in our experiment thought that the message was not personalized when the message was sent out randomly. At the same time, for personalized group, more participants perceived the message to be personalized. Therefore, we posit that our system is capable to push out mobile advertising to target people.

In order to know exactly the detailed differences between personalized group and random group, we asked our participants: "Do you think in what way the message is personalized for

you, such as food type, location of the restaurant, weather, time, income". As we find in table2(Q8), there are more items matching participants' interests in personalized group than random group. A significant difference exists between the two groups. We can see clearly that less than 3 items were perceived to be personalized in random group while the results for personalized group were the opposite.

Attitude toward the message

As for participants' attitude toward the message, a significant difference exists between personalized group and random group (chi square=7.922, p<0.05). More participants who fell into personalized group held a positive attitude toward the message. This confirmed the prior studies which showed the importance of personalization on consumers' attitude toward mobile advertising (Haghirian et al. 2004; Tsang et al. 2004). This also proved that our system is valuable and effective to change people's attitude toward mobile advertising to some extent.

Intention

When we asked our participants: "whether they are willing to receive the message", the results displayed at table2(Q3) were out of our expectation. We hypothesized that participants in personalized group were more willing to receive the message than the ones in random group. We think the reasons for the results might be: (1) the content of the message was very close to students' life, they may think it is interesting to receive such kind of message whether it is personalized or not. Many participants had exposed their favorable feelings about the content of the message (from what they had written on our questionnaire); (2) young people were more tolerant toward mobile advertising using SMS than elder people, so the message might not irritate them a lot while comparing with older people.

Behavior

There are a variety of responses for mobile advertising. As what we employed in our experiment, we first asked the participants: "whether they will read the whole message after receiving it". If people who receive mobile advertising don't read the message, it's impossible that they would use it and go for purchase or consumption. Table2 tells us that most of our participants were willing to read the whole message before deleting it both in personalized group and random group. Participants in personalized group were not significantly different from the ones in random group on reading the message. This result might also be explained at the same way as the question focusing on intention. Young people were innovative and active to the new technology, so they might not care much on what type of message it is.

After that, we also tended to understand whether our participants would remain and forward the message. As we posited earlier, this extra result would bring more benefits to the success of SMS advertising. Unfortunately, we hadn't found this kind of effect in our experiment. Most participants whether in personalized group or random group exposed that they would not remain and forward the message to others. Maybe the reason for this is that the message we used in our experiment is not interesting. Barwise and Strong (2002) posited in their paper that mobile text adverts could be forwarded for especially entertaining or informative ones. Moreover, the capacity of our mobile devices for storing messages is very limited, so they didn't want to transfer the message to others or remain it in their mobile devices.

At last, we asked our participants the most important question which often was used to evaluate the effectiveness of advertising both for traditional advertising and mobile advertising. Just as table2 shows, we want to know whether our participants would accept the promotion and go to consume. The results turned out to be what we expected. Participants in personalized group were more likely to go after receiving the message than the ones in random group. From this, we find that personalization is important for mobile advertising. The result also clearly indicates that our system is effective to deliver personalized mobile advertising using SMS.

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