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A Personalized Assistant in 3D Virtual Shopping Environment

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***Abstract*—Virtual reality (VR) and data mining techniques are widely used in E-commerce. This paper discusses the integration of personalized recommendation system in 3d virtual shopping environment. Our approach has two obvious features: one is the personalized recommendation based on data mining technologies, which means the system enhances the customer desired product attributes by utilizing his/her past purchases, and the other is the application of 3D graphical representations to achieve the realistic and human-like shopping experience such as the personalized avatars, and collaborative interaction between the customers. We experimentally evaluate the system on a real-life data in order to assess its potential usefulness. The methodology discussed here can be useful for customers in making a better choice of the target product in virtual shopping environment.**

Keywords- E-commerce; VR; personalized assistant; data mining; 3d virtual shopping

I. INTRODUCTION

With the rapid expansion of the Internet, E-commerce and online shopping applications are expected to become one of the fastest growing fields in the Internet market. However, the exponentially increasing information along with the rapid expansion of the business Web sites causes the problem of information explosion. Consumers have to spend more and more time to browse the network before they select which products meet their needs. As a result, the need for new marketing strategies such as one-to-one marketing and customer relationship management (CRM) has been stressed both from researches as well as from practical affairs [1, 2, 3, 4]. Intelligent guide is such a solution to provide the most appropriate products for the customers through personalized recommendation technique. However, most of the current E-commerce platforms only provide customers simple, 2D image-based and text-based interfaces or some flash animations to access the products. Recreating lifelike environments make it easy for customers to access and accept computers and the connected benefits offered via the internet.

A. Review of Literature

The techniques in the literature on product recommendation include data mining, knowledge discovery, collaborative filtering etc [5, 6, 7, 8]. Saward provides a Case-Based Reasoning (CBR) approach to efficient product recommendation. As cause this approach, every product in the database is represented as a case consisting of set of features and attributes. They also suggested an iterative relaxation CBR cycle to effectively capture the customer requirements [11]. Yager provides a fuzzy logic based methodology for constructing recommender systems. This approach utilizes a single individual's preferences for generating recommendations as opposed to Collaborative Filtering (CF) based methods that uses preferences of collaborators. He has concluded that reclusive methods can act as complementary to CF based methods. Yager has also pointed out that optimal recommender systems should be based on a combination of collaborative and reclusive methods [12].

Like most advancements in internet technique, virtual shopping mall integrates e-commerce with 3D virtual environments, which creates an appealing interface just like real-life shopping environment. VR-Shop, as a demo installation of a virtual shopping environment within a 3D online community, is based on Blaxxun VRML multi-user technique and is capable of providing advanced visualizations in return for a rather lengthy plug-in download. VR-Shop enables companies to offer a complete and efficient service solution for their customers for a faster and better way to communicate and enter the marketplace [9]. Based on the project of ATLAS, CDSN Lab, Information and Communications Univ., Korea, developed a 3D shared virtual shopping mall. The main goal of this project is to design and implement a scalable network framework for large distributed virtual environments [10].

B. Problem and Our Approaches

We consider the major shortcomings of all of the above approaches are that they do not integrate e-commerce with product recommendation technology and 3D virtual environments.

Our work intends to bridge the gap between e-commerce, personalized recommendation, Virtual Reality (VR) and communities to create an integrated framework for the interactive virtual shopping mall on the Internet. In this virtual shopping mall, the customer can view and interact with others almost like in the real life, include intelligent agents, other customers and merchants. The work is separated into three steps: (1) The creation of the personalized recommendation system. We take into consideration the customer's profile to personalized product recommendation. (2) The creation of the virtual shopping environment, which permits the customers to navigate

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around the virtual mall and select products with image-based presentation and customization technique. We also use 3D graphical representations of the participants (avatar) to raise acceptance and usability for the customers by providing a more natural interaction with the medium Internet. (3) The embedment of the above techniques.

The rest of the paper is organized as follows: we present the personalized recommendation system in Section 2. In Section 3 the personalized recommendation algorithm is discussed. In Section 4 the virtual shopping environment is described. Experiments and evaluation of system is presented in Section 5. Finally, we summarize the contributions and directions for future research work in Section 6.

II. ARCHITECTURE OF PERSONALIZED RECOMMENDATION SYSTEM

First, we provide product recommendation architecture and describe its various components in detail. Second, a recommendation methodology is suggested and a step-by-step illustration is also provided to enlighten the procedure.

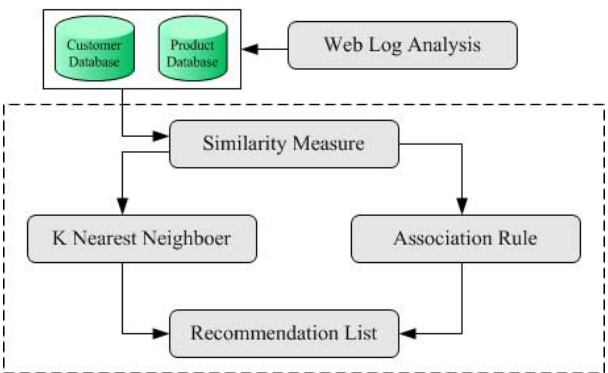

Figure 1. Architecture of personalized recommendation

The personalized recommendation procedure is provided in Figure 1, which is the core component of the system. In the personalized recommendation phase, five processes are identified. The customer will usually start the transaction by the text input which represents the customer's requirements. In the intelligent guide system, many types of information are stored in the customer database especially the customer's profile information (e.g. gender, age, occupation, etc.) and the products that the customer has bought in the past. According to this information, then customers can be split into several personalized areas by similarity measure. The third process-the product selection divides into two parallel steps. One the one hand, k Nearest Neighbor is employed to find the most appropriate products for the target customer in these different preference areas. On the other hand, these nearest neighbors' transaction database can be used to generate products association rules that are specific to the target customer. Finally, the recommendation list shows the recommendation products and associated products to the target customers.

III. PERSONALIZED RECOMMENDATION ALGORITHM

The first process monitors the user input and extracts the customer purchase information. The extracted data are preprocessed and stored in the customer database. However, in this paper, we presume that the customer database is available. These related purchase data are organized on customer identifiers and transformed to the next process when requested.

A. Similarity Measure

There is a similarity measure used to calculate a customer's neighbors in common. Correlation-based similarity: in this case, similarity between two customers i and j is measured by computing the person r correlation $corr(i, j)$ lets the set of items which are both rated by customers i and j be denoted by I_{ij} , then the correlation similarity is given by

$$sim(i,j)=\frac{\sum_{c\in I_{ij}}\{R_{i,c}-\overline{R_i}\}\{R_{j,c}-\overline{R_j}\}}{\sqrt{\sum_{c\in I_{ij}}\{R_{i,c}-\overline{R_i}\}^2}\sqrt{\sum_{c\in I_{ij}}\{R_{j,c}-\overline{R_j}\}^2}} \tag{1}$$

Here $R_{i,c}$ denotes the rating of customer i on item c , R_i is the average of the $i-th$ customer's rating.

In our paper, we introduce another modified method based on the above similarity measures. The customers' similarity module in our system is constructed based on the following four general shopping steps: (a) Text: the texts inputted by the customer reflect the customer's requirement; (b) Click-through: the click on the products and the view of the relative products; (c) Purchase: the completion of a transaction; (d) We also add non-purchase products. From the investigating and analyzing, as a factor, the non-purchase also affects the accurate of evaluating to customer's similarity, so it can think that the customers who view the same product, but not purchase products have the similar shopping habit.

From the above discussion, we first normalize shopping records of customers from 0 to 1, as follows:

$$C_{ik}=\frac{i_{ik}-\min_{1\le k\le N}(i_{ik})}{\max_{1\le k\le N}(i_{ik})-\min_{1\le k\le N}(i_{ik})} \tag{2}$$

Where i_{ik} represent the number of the $i-th$ customer who bought the $k-th$ item, $k=1,\cdots,N$ (total number of products).

$$Similarity(i,j)=\left[\frac{\sum_{k=1}^{N}(C_{ik}\wedge C_{jk})}{\sum_{k=1}^{N}(C_{ik}+C_{jk}-(C_{ik}\wedge C_{jk}))}\right]_{\{click,text,real-purchase\}} +\lambda\left[\frac{\sum_{k=1}^{N}(C_{ik}\wedge C_{k})}{N}\right]_{non-purchase} \tag{3}$$

$$X_{ik}=[C_{ik}]_{\{click,text,real-purchase\}} \tag{4}$$

Where $Similarity(i, j)$ represents the customer i and the customer j similar matrix; X_{ik} represents the customer and product similar matrix.

B. K Nearest Neighbor

In each group we use the K nearest neighbor to calculate the preference between customer and product.

$$R_{ak} = \sum_{i=1}^{k} Similarity(a,i)X_{ik} + Similarity(a,a)X_{ak} \quad (5)$$

Where X_{ik} represents the preference between customer i and product k ; $Similarity(a,i)$ represents the similarity between customer a and customer i ; R_{ak} represents the preference between customer a and product k computed by the customer's neighbors.

C. Association Rule

The steps for mining association rules from different transaction sets are as follows:

- Step 1: Gather all the neighbor transactions made into a single transaction in the form of <customer id, {a set of products} >.
- Step 2: set minimum support and minimum confidence. Support =# of neighbor transactions containing items in $x \cup y$ / total # of neighbor transactions in the database. Confidence =#of transactions that contain both x and y /#of transactions containing.
- Step 3: replace each product in transaction set with its corresponding higher product class.
- Step 4: given a size w , find all frequent item sets of size w using Apriori or its variants.
- Step 5: generate association rules from the set of all frequent item sets of size w .

It should be noted that minimum supports and minimum confidences can be specified for different similar groups in step 2. Discovered association rules (rule types) are given by $x < \overrightarrow{group1} > y$.

IV. The Virtual Shopping Environment

The multi-user virtual shopping environment provides avatar representations and nicknames for identifications. Depending on individual interest and preference customers might select the virtual avatar by themselves from the pre-defined avatar libraries. The customer profile such as interests, status and preference will be attached to the selected avatar. With the help of attached web individual profiles can be described. In particular, three types of information are administered by customer database: the customer's profile information (e.g. name, gender, age, etc.), the products that the customer has bought in the past and the time and date of the customer's previous sessions. The environment sustains the multi-user collaborative shopping. All objects in the environment can be perceived by all customers who are present in the distributed area at the same time. The customers can communicate with each other by text or video chat. Depending on roles in the shopping mall, pre-defined body gestures for the avatar is selectable, such as agree or dislike, which gives the customer a feeling of being an active part of the real life by using VRML, Java3D and multimedia to implement product presentations.

A. Architecture of System

The overall client/server architecture of the environments has a four-layer client/server architecture that includes the client layer, the interactive layer, the multi-agent engine layer, and the server layer.

The environment is separated into two parts: the server side and the client side with internet in-between. The client side and server side can be at any place that is connected to each other through the internet. The main servers include the file server, the database server, the WWW server, and the 3D object server. The multi-agent engine component is also equipped on the server side. The file server contains pre-made HTML templates, which are for the dynamic pages. The 3D object server contains the 3D product models, and the 3D avatars. The initial database, such as information on customer profiles, products or purchase history, is stored in the database server.

B. Interactive Strategy

The traditional distributed system is based on a central server model. Clients only communicate with the stand-alone server, which contains the entire scene database and tracks all objects of interest within the system [13]. A solution for this problem is the subdivision of large virtual worlds into several regions or zones. Each of the areas in the virtual environment has its own boundary and world coordination. The VRML/Java3D-enabled browser uses Java as its scripting language. The script nodes in the VRML scene point either to a local Java script, or to Java scripts on remote servers. Scripts are able to manipulate scene graph nodes by generating events that are delivered to the node and change one or more of it properties. The avatar is aware of events occurring in its 3D scene. Events are communicated by the XML via an External Authoring Interface (EAI).

In environment the trigger agent is equipped with three sensors, which alert it of events in the environment and some customer states. These are:

- Proximity Sensor: alerts the trigger agent of the position and orientation of the customer's avatar with respect to a fixed point in the 3D scene. This enables the proximity sensor to track the avatar's coordination. The coordination is represented by $[Q, X, Y, Z]$, where Q represents the id of certain shopping area which the avatar is in, (X, Y, Z) represents the avatar's position information in the shopping area. For example, when an avatar walking inside the boundary of T-shirt area, the sensor transmit the information to scene control model, so it refreshes and synchronously updates the corresponding data on the participating avatar.

- Visibility Sensor: alerts the trigger agent when a particular object is in the avatar's field of view.
- Touch Sensor: alerts the trigger agent when the customer avatar clicks on a virtual object. These sensors allow the trigger agent to have awareness of its context.

This is helpful in disambiguating utterances received from the customer, which refer to objects in the 3D scene.

V. Experiments and Evaluation

The intelligent guide system is examined in our virtual shopping mall system. All tests were performed on Pentium Ⅲ PCs running Windows 2000 and connected to a 100 Mbps Ethernet. The display was set a 1024*768 32bit color screen resolution with 3D accelerator cards.

In order to assess the approach proposed and the system developed, we select 300 participants from different occupations, split into two groups according to gender and five kinds of products are provided. In the experiments, we concentrate on evaluating the quality of recommendation from MAE (Mean Absolute Error) as the evaluated standard.

$$MAE = \frac{\sum_{i=1}^{N} |p_i - q_i|}{N} \% \tag{6}$$

Where p_i represents the degree of satisfaction that the customer assess the product, q_i represents the degree of satisfaction that recommendation algorithm assess the product, and N represents the total customers.

The system runs on various platforms. We have tested our system on the several operating systems, such as: Windows 98, Windows 2000 and Windows XP, with the browser Internet Explorer 5.0 (plug-in: Blaxxun Contact5.1) or later.

VI. Conclusion and Future Work

E-commerce is becoming an important component of modern business transactions, but the current e-commerce systems still lack many important features. Our research has addressed these deficiencies and we have so far provided promising solutions. We have integrated virtual reality and data mining approaches to realize the recommendation of products and life-like navigation in 3D virtual shopping mall. Thus the customers can experience more and more functionalities that they encounter in an actual store or mall.

But there are still a lot of further work is necessary to improve these features. Our future work will concentrate on improving the efficiency of recommendation and enabling the avatars with affective expression. In addition, the experimental system will be subject to a number of user tests in order to evaluate their responses to this approach and needs to be put in use in commercial virtual shopping mall.

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