Modeling Personal Preference Using Shopping Behaviors in Ubiquitous Information Environment

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Abstract We have been developing an experimental prototype system -- Smart Shop, an application of personal information assistance in a shopping context, (1) to find items of users' interest and/or preferences through data observed from users' behaviors in a ubiquitous information environment, (2) to automatically build a user preference model, and (3) to apply the model and provide suitable information service in the real world. Utilizing ubiquitous sensors, we apply three types of observation scopes to model each user's preference. They are microscopic, mezzoscopic, and macroscopic observation scopes. Our system can inject suitable and controlled messages to a user to build up his precise preference model without putting any stress on him.

Keyword Information Services, Personal Preference, Smart Shop, Shopping Assistance, Ubiquitous

1. Introduction

Currently, computer information systems are increasingly being used in the fields of marketing. For example assisting clients in making purchases at a large store handling massive amounts of different types of products in which the computer information systems provide searching abilities to navigate consumers to a specific product; a floor information system in a department store and a book search system in a book store. The system usually comes in the form of a computer screen showing product attribute search fields in which clients can input some attributive information of a requested product to obtain additional information; such as product profiles, color, and shape. However, these kinds of systems seem to be inadequate in assisting clients who have no certain idea about what kind of product suits their needs. More intelligent systems offer more interactive functions to clients, providing several input dialogue fields on the computer screen with respect to the client personalities and interests, and then recommending products based on that information. However, these kinds of systems are rather awkward for most typical clients. Such systems force their users to answer a huge number of questionnaires to describe the individual preferences. It takes significant time and patience to answer and enter the required information into the systems to generate an appropriate model to recommend an appropriate product. Thus, next-generation computer information systems are needed. They should be able to learn or adapt to client demands naturally, instead of the simple manual input data method.

Recent developments in Information Technology are making electric household appliances computerized and networked. If the environments surrounding us could recognize our activities indirectly by sensors, the novel services, which respect our activities, would be possible. This idea was initially proposed by Weiser as ubiquitous computing [19] and are emerging as Robotic Room [11], Intelligent Space [15], Easy Living [16], Smart Rooms [17], etc. One of the most important factors for such systems is the recognition of human intentions by using ubiquitous sensors. Intelligent Space detects the positions, which are recognizable from the external observation of a human, by using multiple cameras on the ceiling and drives a mobile robot to follow the human [15]. Easy Living also detects the position of the human and turns on a light near the human [16]. These systems are considered as providing services by taking account of human intention on where the human intends to move.

In this study, we propose a modeling of personal preference through shopping behavior and its application to shopping assistance service in a ubiquitous information environment. Our basic ideas are (1) to find items of users' interests and/or preferences through data observed from users' behaviors in a ubiquitous information environment, (2) to automatically build a user preference model, and (3) to apply the model and provide suitable information service in the real world.

2. Modeling Personal Preference

In a shopping context, consumers usually spend more time looking at items (information or product), which they like, rather than those they do not. Thus, viewing time, and behavior towards items, may provide a means of identifying consumer preferences, or propensity to consume a product or information service.

We assume that the time that consumers spent in front of goods on the shelf may be a good predictor. We also assume that consumers will touch items in which they have an interest. We hypothesize that a consumer is interested in an item when he touches and stays in front of the item for a length of time.

We defined observation methods to monitor a person's behavior to make a personal preference model. We also defined management methods for providing a personalized recommendation using personal preference models.

Observation Methods for Modeling Personal Preference

Utilizing ubiquitous sensors, we apply three types of observation methods which are Microscopic, Macroscopic, and Mezzoscopic view as shown in Fig.1 to model each user's preference.

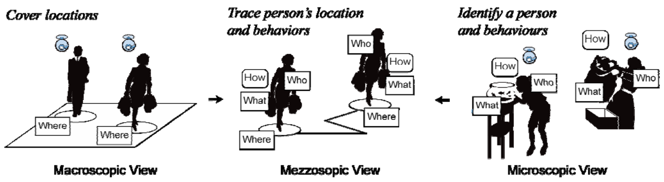

Fig.1. Behavior Observation Viewpoint

- Microscopic view
  Microscopic view identifies a user from his/her RFID nametag and some handling motions on some item by locally equipped cameras.
- Macroscopic view
  Macroscopic view covers the location of each person in a space by a matrix of global view cameras located on the ceiling. It also covers the overall spatial allocation and density of the people as well as the items in the space.
- Mezzoscopic view
  Mezzoscopic view extracts and traces each person's location and behavior as a time series by using the data from microscopic and macroscopic views.

Indirect Interaction in Active Observation

The enforcement of answering a huge number of questionnaires on users is a bottleneck in modeling personal preferences. One idea is just taking their behavior log via ubiquitous sensors, without asking them, and mining some specific features by statistical analysis. Such a method is called passive observation. The problem of this method is that it requires long time and huge personal log to cover enough behavior data.

Our idea is to show several messages to each user, i.e., applying active observation, without expecting direct answers. If a message is informative and interesting to a user, he may pay attention, gaze, and follow the suggestion according to the message. In this process he is freely behaving by his intention without feeling any enforcement to answer to the system. In this case, monitoring each user's behavior, i.e., responses to the messages, via ubiquitous sensors enables to attain enough behavior data effectively. This method corresponds to indirect interaction in active observation.

Classification of behaviors

We defined behaviors of a consumer towards items in Table **1** 1., and also showed the definitions for behaviors evaluations in Table 2.

Table 1 Definitions for Behaviors towards Items

Actions	Definition
Standing	The state in which a consumer stop by at a certain distance before a certain object.
Viewing	The state in which a consumer looks at a certain object.
Touching	The state in which a consumer touches a certain object where the object does not separate from its shelf.
Carrying	The state in which a consumer separately picks up a certain object from its shelf.
Fitting	The state in which a consumer uses a mirror to match a certain object with his/her appearance.

Table 2 Evaluations of Actions towards Items

Evaluations	Definition
Period	The time that a consumer spends on a behavior as a second.
Frequency	The number of times that a consumer has a behavior.

Management Data on Modeling Personal Preference

We defined three databases (DB) to maintain data on Microscopic, Macroscopic and Mezzoscopic view devices as Micro DB, Macro DB and Mezzo DB for modeling personal preference.

For maintaining data on persons' locations and behaviors in those locations, we define three database schemas based on these following points. The relationship between five contexts (4W1H) can be an answer to the question of when, where and how to recommend information/services or products to the consumer.

WHO: "WHO" is an attribute to manage persons' identities. In this shopping context, "WHO" means an identity of a regular or a store consumer. This data will be obtained from microscopic view devices.

WHAT: "WHAT" is an attribute to manage interesting items (information or products), which are attracting a consumer's attention. In this shopping context, "WHAT" means items (clothes and goods) in which consumers have interest. This data will be obtained from microscopic view devices.

WHERE: "WHERE" is an attribute to comprise a consumer's location within a place. This data will be obtained from macroscopic view devices.

WHEN: "WHEN" is an attribute to trace chronological information, which are generated when a consumer is visiting a shopping store and walking around. This data will be obtained from microscopic and macroscopic view devices.

HOW: "HOW" is an attribute to represent gestures or actions of a customer. The gestures consist of body motions, positions of hands, and movements of head. This data will be analyzed data from microscopic and macroscopic view devices.

We show three database schemas as follows:

Micro DB: Micro DB manages data on consumers' identities, which are obtained from the microscopic view devices. Described by the schema below:

Micro (Who, What, When, How)

Macro DB: Macro DB structures and store data obtained from the macroscopic view devices. Described by the schema below:

Macro(Who, Where, When)

Mezzo DB: Mezzo DB structures and stores data by analyzing a relation between each person's behavior towards items and feature data of interesting items from fused data of macroscopic, microscopic view devices. Described by the schema below:

Mezzo(Who, What, Where, When, How)

The Algorithm for Modeling Personal Preference

The algorithm for modeling personal preference is as following.

1. It checks the place of a consumer by Macroscopic device and identifies the consumer by Microscopic device.
2. It accumulates data on the consumer's actions towards items with his/her identity and information on these items using Microscopic devices.
3. It finds common features of items, in which this consumer showed interest, by analyzing features of accumulated data. These common features are called a preference model in this study.
4. It recommends personalized item information to the consumer, based on his/her preference model.
5. It collects data on the consumer's reaction towards a recommended item in order to find further item features used to remodel.

This study uses a multiple linear regression analysis as an analyzing method. Personal preference models simulate a correlation between consumer actions and items. These models are accumulated in a personal preference model database with an original ID.

Then this feature information is used as a reference to obtain a list of the other products possessing common features. For instance, if a consumer touches a blue cloth for some extended time, it is assumed that the consumer may have an interest in blue color. Then the other kind of blue cloth may possibly be of in interest to him/her.

3. Shopping Assistance Service

In the business field, finding consumers' preferences is an important matter. Points of sales systems are popularly used to detect a current consumer's preferences as well as in store management. From the aspect of a ubiquitous information environment, future store projects, for instance, proposes a smart shelf to monitor their goods with RFID tags in real-time, communicating information with the store server as well as a consumer's shopping cart.

The basic idea still remains in a passive observation scheme while it refers personal preference data of each consumer. We have been developing an experimental prototype system, Smart Shop, as an application of personal information assistance in shopping context (Fig. 2). This Smart Shop system was made utilizing Java, C and PostgresSQL on Fedora Core Linux.

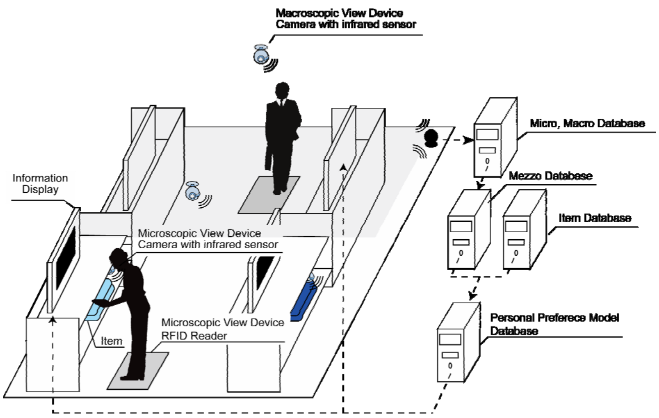

Fig. 2. System Overview of Smart Shop

A. Microscopic View Devices

Each shelf is equipped with (a) an RFID tag reader to identify each consumer around the area, (b) several item cameras to detect his/her behaviors, related to the items, such as touching, grasping and wearing, and (c) several LCD monitors to show personal messages to him/her, as well as to show public messages to the consumers.

B. Macroscopic View Devices

The ceiling of the shop is equipped with a camera array to cover the entire area, without occlusion, to detect the location of each consumer at each time slice.

C. Databases

We have five types of database servers:

(a) Micro DB. To detect each behavior of the customer by image processing with his/her customer-ID by an RFID reader at each shelf.

(b) Macro DB. To integrate location data of consumers from camera array by image processing at each time slice.

(c) Mezzo DB. To integrate relation data on personal behavior in each location and items, using observed data from Micro DB and Macro DB.

(d) Item DB. To manage items in the shop.

(e) Personal Preference Model DB. To statistically analyze each customer's preferences from each of his/her behavior logs.

We make a personal preference model using Mezzo DB and Item DB. The Item DB has features such as color and material, of items in this store.

D. Shopping Assistance Service

We describe how to provide shopping assistance service when users come to shop, and how to provide recommendations when users seem to be interested in some products.

a) Don't disturb services/Advertising Mode

It will be the first mode for new customers. It will show the Welcome Message, Advertising Message, and recommendation message on some items.

This mode is similar to general information display. It is an idle mode for the customers who are screening the products but not looking at the screen.

This mode will show when customers pay attention to the items or walk away from those items.

b) Push Services/Personalized Recommendation Mode

This mode is designed for returning customers. It will show special welcome messages plus customer names as well as providing the Recommendation base on user preferences (Fig.3).

This study is applied from the method of Content-based, Collaborative and Hybrid Recommendation.

The assistance offered to consumers is in the form of recommendations about new products, product discounts, special offers, etc. All recommendations are tailored to the consumer's personal preference.

The products that received the most frequent interest (viewed, touched, purchased) are those that the system will finally recommend.

In the case where customers show interest in the recommended product: The system shows related information, such as similar items with locations in the shop, or detailed information about the item.

c) Searching Services/Navigation Recommendations Mode

This mode is for new customers who are not familiar with the layout of the shop and may require more time in wandering around the shop and end up not being able to find the wanted product. In addition, the products available in the shop are not displayed on the shelf. This mode is also for customers who purchase the products for others (buying for a gift).

This is also the case for all new customers visiting the shop for the first time, and for returning customers who want additional products. If the customer shows interest in the screen display, it means that he or she needs some information. He/she can input information about the required item. This helps save purchasing time, provides information about what products are available, and helps the customer become aware of whether or not the needed product is available. The system shows similar items information with location in the shop.

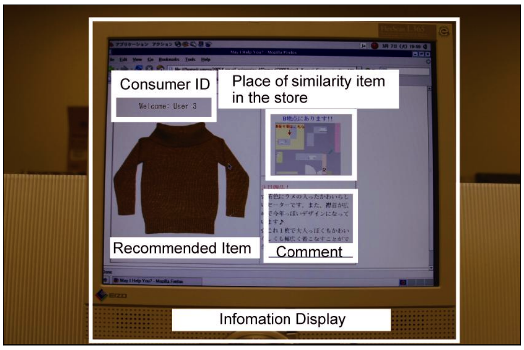

Fig. 3 Example of Personalized Recommendation

The system functions are as follows:

(1) If a customer comes to a shelf, its microscopic server is activated and senses his/her RFID for identification.

(2) If he/she is a returning customer, the system shows a special welcome message plus some "today's news" on items suitable for his/her preference selected from the recommendation server and filtered by the preference server.

(3) If the customer is new, the system shows a popular welcome message plus a recommendation message on some item, which is a learning example for statistical analysis, selected from a recommendation server.

(4) The microscopic server monitors his/her eye line as well as motions concerning the items there.

(5) If the customer pays no attention to the message, or to the items on the shelf, the system records his/her response into their behavior log in the mezzoscopic server and also updates their preference data in the preference server. The system then shows another message on items suitable for his/her preference selected from the recommendation server and filtered by the preference server.

(6) If he/she pays some attention to the message or to the items there, the system records his/her response into their behavior log and updates the preference data in the preference server. The system also shows related information, such as similar items with location in the shop, or detail information about the item.

Through this process and iteration, the system can build up and update each customer's preference model without forcing him/her to answer huge questionnaires. Of course, each customer receives only valuable messages and assistance from the system.

4. Experiment

At present, we have already tested our model with real subjects (as customers). We have built a 30 square meter room employed as Smart Shop. Six units of items display shelves (as used in a general store) were installed. Each shelf carried an information display (EIZO FlaxScan L365) on the top level, so that subjects would be able to easily see information presented on the screen when he/she selected items, and four pieces of cloth, different in color and type, on the lower levels.

RFID units (OMRON V720 Series) were used to identify subjects if he/she approached the front of the shelf. Therefore, subjects participating in this experiment can be a real subject, wearing different tag ID cards to mislead the system to evoke different profiles for different customers. Four cameras (Panasonic Network Camera BL-C31) were used for each shelf to monitor hand motions of the subjects. The other camera placed on the ceiling was used to monitor location of the subject in the store. We used the Fedora Core Linux operating system for showing item information in the store through a web browser.

Sixty-four pieces of clothes were randomly selected to be placed on the shelves throughout the experiment. Two real subjects participated in the experiment. They wore different tag ID cards to simulate ten different customers. Subjects were invited into the Smart Shop one at a time. Each subject was randomly assigned to do one of the following tasks; 1) picking up a preferred color item, 2) picking up a preferred type item, and 3) picking up a preferred color and type item. The instructions given to the subjects were, for instance, simply as follows: "please go into the Smart Shop and feel free to spend your time for as long as you wish, in order to pick up a most preferred color item". Each "tag ID simulated subject" conducted the experiment one time.

The experiment here emphasized finding the item that attracted the customer, and then building up his/her preference model, although as we mentioned at the beginning, the complete system would be also able to apply the model to provide suitable information in the right place and time. This is because the next stage of the system requires a much more up-to-date empirical database to achieve the goal, for instance a popular color for men and women for each season, and a popular color for elderly persons for each kind of product, in addition, to interactions of people at different ages to the information displayed. Therefore we will leave the emphasis of the next stage of the system, to future work.

For this reason, we expect that the system should be able to present an appropriate kind of competitive product while the subject is considering an item. For example, if the subject is holding a blue item in his/her hand, the information screen would present another type of blue item.

Table 3. The Rate of Correct Detection and False Detection of Observation.

Subject 1	Correct Detection	92.0 (92/100)
	False Detection	8.0 (8/100)
Subject 2	Correct Detection	94.0 (94/100)
	False Detection	6.0 (6/100)

The rates of correct and false detection observation are shown in Table 3. When subjects touched the interest items, the average correct detection rate was 93.0%, and average false detection rate was 7%. These results show that the observation step is possible from the customers' behavior as recorded by the system. The system could find the item attracting the customer, build up his/her preference model and simply recommend the product to the customer.

It compares the operation of the system by identifying software simulation as the real usage of human beings. This sometimes shows the mal-functionality of the sensor. For instance, the censor detects that there is a real customer but in reality there is no customer. Another example is that a customer touched the product but the sensor didn't show the result. The system needs a module to decrease these errors from ubiquitous sensors. In this stage, the inspection between macroscopic and microscopic is used – to touch the product (Microscopic) and to show the information that there is a customer at the position and at a specific time (Macroscopic).

5. Evaluation

This study evaluated the accuracy of a personal preference model, based on our framework, by examinees having their actions observed while purchasing items of interest in the Smart Shop. The evaluation experiment of modeling personal preference was conducted by using 19 examinees as customers three times. The examinees came to the clothes store independently three times and bought the clothes in which they were interested. The examinee could feel free to move around in the store.

The Smart Shop system registered the identity of each examinee in the consumer database before starting the experiment. In the first experiment, the system made an individual model of each examinee by observing their actions towards clothes, and analyzing common features of the clothes in which they showed interest though their actions. In the second and third experiment, the Smart Shop recommended personalized clothing items through information on a display, and it accumulated data on consumers' passive reactions to the recommended information. Clothes items in the shop were replaced after the first and second experiment.

The recommended information about clothes was decided by the personal behavior model for each examinee, which was made in the first experiment. The system showed the recommendation information about clothes, to the information display in front of the examinee, when it observed consumer identity or presence by microscopic and macroscopic devices. The experiment gave questionnaires to each examinee about satisfaction of personalized recommendations.

Table 4. Number-of-times and Average about Human Reaction to Recommended Personalized Information

	Moved	Not Moved		Moved	Not Moved
ExamineeA	4	4	ExamineeJ	4	2
ExamineeB	6	3	ExamineeK	4	1
ExamineeC	2	3	ExamineeL	3	1
ExamineeD	3	2	ExamineeM	5	1
ExamineeE	3	2	ExamineeN	1	3
ExamineeF	4	2	ExamineeO	1	1
ExamineeG	0	1	ExamineeP	1	5
ExamineeH	7	5	ExamineeQ	5	3
ExamineeI	2	2	ExamineeR	0	0
			ExamineeS	5	2

Recommended item	Human Reaction	Number of Action Times	Rate
Personalized Item	Movement to the place of recommended item	60	58.3%
Not Personalized Item	Movement to the place of recommended item	43	41.7%

The experiment evaluated the accuracy of the personal behavior models concerning clothes for each examinee. Therefore, if the recommended information detailing the place of the clothes in the store can direct the examinee to the detailed place in the store, the model is considered a success. Table 4 shows the reaction results of each examinee and their average responses to recommended information. In a successful case, the examinees moved to a place in the store on the basis of their personalized recommendation. On average about 60% of examinees reacted to their personalized recommendation. Examinees whose actions followed clear criteria, for example searching for a certain color and giving the system a clear basis for recommendations, were able to receive a good degree of satisfaction, which became obvious by questionnaires after the experiment.

Table 5. Number-of-Times of which Examinee Looked at the Information Display

	2 exp.	3 exp.		2 exp.	3 exp.
ExamineeA	6	8	ExamineeJ	3	6
ExamineeB	8	9	ExamineeK	3	5
ExamineeC	8	5	ExamineeL	5	4
ExamineeD	7	5	ExamineeM	3	6
ExamineeE	8	5	ExamineeN	2	4
ExamineeF	3	6	ExamineeO	0	2
ExamineeG	1	1	ExamineeP	2	6
ExamineeH	8	12	ExamineeQ	1	8
ExamineeI	4	4	ExamineeR	2	0
			ExamineeS	6	7

Table 5 also shows the number of times that examinees looked at the information display. The result illustrates that each examinee has individual tendencies to view the information. The study also found that examinees, who do not have steady selection criteria for an item, also view the information display. This trend is clearly visible. This experiment illustrates that examinees, who viewed the information display often, went to the place recommended by the shop system. The shop system is efficient as a personalized service system.

6. Conclusions

This paper has proposed the modeling of personal preference through shopping behavior, and has been developing as an experimental prototype system, Smart Shop, in the application of personal information assistance in a shopping context. Our basic ideas are (1) to find items of users' interests and/or preferences through data observed from users' behaviors in a ubiquitous information environment, (2) to automatically build a user preference model, and (3) to apply the model and provide suitable information service in the real world.

Utilizing ubiquitous sensors, we apply three types of observation scopes to model each user's preference. They are: microscopic, mezzoscopic, and macroscopic observation scopes. We are applying active observation, without expecting direct answers. Our system can provide suitable and controlled messages to a user to build up his/her precise preference model without placing any stress on him/her. Thus, the system can statistically and effectively analyze a degree of interest about objects by each person's behavior log without a huge number of questionnaires.

Our further work will include detailed analyses of this model for accuracy, scalability, and efficiency.

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