

Modeling Personal Preferences on Commodities by Behavior Log Analysis with Ubiquitous Sensing

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Abstract. Consumers may take some specific behavior preference or favorite items to get more information, such as the material and the price, in shopping. We have been developing a smart room to estimate their preference and favorite items through observation using ubiquitous sensors, such as RFID and Web cameras. We assumed the decision decision-making process in shopping as AIDMA rule, and detected specific behavior, which are “See”, “Touch” and “Take”, to estimate user’s interest. We found that we can classify consumers by their behavior patterns of the times and duration of the behaviors. In our experiment we have tested twenty-eight subjects on twenty-four T-shirts. In the experiment, we got better precision ratio for each subjects on estimating preference and favorite items by discriminate analysis on his or her behavior log, and behavior patterns classification above.

1 Introduction

In recent year, not only a lot of products have been diversified, but also the consumer's interests to the products are diversified. As a result, when the consumer goes to the store it is difficult for the store to correspond to consumer needs. Thus, there are very necessary to provide information to the consumer and predict the consumer’s interest and preference. From the previous research, when they have interest in a product, they will stare at it or pick it up to take a glance [5][6]. Therefore, when we collect consumer’s preference by observing the consumer’s behavior with ubiquitous equipments such as RFID, sensor cameras [4], we can predict the consumer’s behavior and we can provide the appropriate item recommendation to the consumer in the shop space.

From our study, male consumers tend to decide to buy when spec of item match with their desire while female consumers carefully consider, choose and compare lots of item before decide to buy [3]. That means the consumer takes various behavior patterns.

In this paper, we have been studying about the consumer’s preferences by observing the unevenly consumer's behavior with ubiquitous equipments such as RFID, sensor cameras in the store. We have collected log files data and can predict the consumer’s interested by analyzing the behavior of each consumer from log files.

2 Approach to Understand the Consumer Behavior Pattern

2.1 The Definition of the Consumer's Action in the Shop Space

In this research, we tried to observe the action and the action frequency that the consumer does to the item to presume that is the favorite item. Then, we classify these actions to behavior pattern. We propose three steps actions since consumer recognize in his/her mind until purchase an item. Three steps can be described as follows:

1. Watching an item that interested and still recognize in his/her mind.
2. For an interest item, check material by visual and touch it to watch a price tag.
3. For an interest item, investigate by hand to get information and choose fit size for him/herself.

In this study, we defined three actions of the consumer for the item which are "See" "Touch" and "Take". We can explain each action as follows: "See": this action is in condition to watch an item, and state that checked the direct most moving passage, feel of a material or a price tag, "Take" took the item in a hand, and nearby, "Touch" watched an item and did it with the state that checked it was an item suitable for oneself.

2.2 Comparison with the AIDMA Rule

Generally, the discussion concerning person's consumption behavior is increased, and AIDMA which is a rule and the behavioral economics has become popular.

AIDMA rule [2] is a hypothesis about the process of the consumption action before reaching the purchase of a certain item after a consumer recognize about an item. AIDMA is composed of "Attention (A)", "Interest (I)", "Desire (D)", "Memory (M)", "Action (A)". Because three actions that we defined are regarded about the change of the action called "See" → "Touch" → "Take" and the strength of the interest degree, these are along a process of AIDMA rule (Fig.1). However, these three actions are considered about intention of watching or touching of items, "Memory" of AIDMA rule is difficult to measure then we did not use in this paper.

Based on the above, this research was defined three actions between the processes to purchase items from the perception that consumers which are "See", "Touch", and "Take", and focused on the degree of interest means that this action, and estimates of the consumer preference. But, it is difficult to measure their favorite degrees with the item in one action because there are consumers who often touches and takes it for the item but not purchase. Then, we propose the kind of the action and the frequency of action that we can collect from the behavior log to classify a shopping pattern and to able to presume what kind of item you liked.



Fig. 1. Definition of action process

In this research, we tried to observe the kind of the action of consumer's "See", "Touch", and "Take" to the item and the action frequency, and to classify the consumer into the purchaser patterns such as consumer who often felt after the item and consumer not so according to the kind and the frequency of the action.

2.3 Definition of Actions

We observe consumer's actions which are "See", "Touch", and "Take", the action time, and the action frequency with an ubiquitous sensor such as Web cameras and RFID in the store. We can definite all actions are as follows:

"See: The person is looking at the item" is interpreted as "Presence of the person in front of the item shelf is observed and detection and the person observe someone with the sensor", and the sensor observes the state, it is assumed "See". Moreover, when it interprets as "The sensor that observes changing the item that exists in the item shelf and the person observes someone", and the sensor observes the state, the state "Touch: Feel after the thing" is assumed to be "Touch". And, when it interprets as "The item that exists in the item shelf disappears", and the sensor observes the state, "Take: The thing is taken up" is assumed to be "Take". In this way, it makes it to the amount here of catching in the state that the movement of the person, the hand, and the item can be observed with the sensor.

2.4 Classification of Shopping Pattern by Clustering

The consumer is divided according to various behavior patterns such as people who often take the item of the favor and person not so from Chapter 1. Thus, after it divides into the behavior pattern that uses the action log to the item, we were able to presume consumer preferences high accuracy by the analysis in each pattern.

As technique to divide a consumer according to a behavior pattern, we perform cluster analysis. When the frequency of "See" "Touch" "Take" that a certain consumer acted for one item is defined as each x_{See} , x_{Touch} , x_{Take} , Each average and decentralization of each action that the person acted for two or more commodities is defined respectively as x_{SeeAve} , $x_{TouchAve}$, $x_{TakeAve}$, x_{Seevar} , $x_{TouchVar}$, $x_{TakeVar}$. We were able to divide two or more consumers by the shopping pattern by the division method of the cluster analysis with using these six variables and the number of consumers. That means we were able to classify it by a person with a lot of action frequencies and little person by the use of the average and the decentralization of each action frequency of the consumer as the variable.

2.5 The Judgment of the Favorite Item by the Discriminant Analysis

By using the cluster analysis after it divides from the consumer's behavior into each behavior pattern, we investigate how to like each item by using the questionnaire, and the objective variable is a degree of the favor of the item and the explanatory variable is action frequency x_{See} , x_{Touch} , x_{Take} in which it acts for each item, and the distinction analysis is done. Thus, we can presume the item of likes and dislikes by calculating the distinction coming true rate of the favor and the probability according to the misjudgement using action frequency of each action.

3 An Evaluation Experiment

3.1 Experimental Overview

Consumer's behavior pattern was classified by using the proposal technique of this research in the shop space with an ubiquitous sensor, and it experimented on the utility of the presumption of the item of the favor. The explanation, the processing method, the content of the experiment, and the experiment result of the sensor used to observe the purchase space, "See", "Touch", and "Take" constructed to experiment are described as follows.

3.2 Experiment Environment

3.2.1 Construction of the Real World Purchasing Space That Used an Ubiquitous Sensor

We constructed the observation and the analysis system. We call Smart Sphere System (SSS) of the real shop space with various sensors that we call an ubiquitous sensor (Fig.2). Ubiquitous sensor is composed of sensor cameras and RFID as System that observes action (Take, Touch, See) and time and frequency of the action on item and calculate the relation between the action and the interest of the consumer who did each behavior pattern.

In the experiment, the space that set up six item shelves named point A to F was constructed as a store in the laboratory. Web camera (BL-C31) made by the Panasonic company that stops taking a picture after it finished taking a picture of the image at regular intervals when the change occurs in the place of which it takes a picture to the ceiling and the shelf of each point, and it taking a picture of a constant image is set up, and the RFID reader made by the OMRON company (V720 series) is hidden under the floor in front of the item shelf (Figure 2). The subjects were supposed to shopping freely in the shop space and wear slippers that have RFID card that was recorded ID (= customer number) that identified each one. Moreover, SSS is connected with all ubiquitous sensors in the store, analyzes the data that has been sent from those ubiquitous sensors, and accumulates consumer's each behavior log.



Fig. 2. Smart Sphere System



Fig. 3. Observation image with ceiling camera

3.2.2 The Personal Certification That We Used RFID

The experiment authenticates the consumer by using RFID. When the consumer who put on slippers that has the RFID tag comes in front of the item shelf, SSS attests who you are there with the RFID reader that hided under the floor in front of the item shelf. In this experiment, when the RFID reader observes tester's RFID tag, This system stores the data of observation time, the customer number, and the place of the item shelf in the database named "RFID" on SSS, and leaves it as an observation log. However, it was likely to cause interference when there were three people or more who had the RFID tag in the same shelf on the performance of this RFID reader, and the customer number wasn't able to be read correctly. Thus, each action can be observed even if two or more customers shop at the same time in SSS if it limits it up to two people per one shelf though it is difficult for this system to observe two or more testers with one item shelf.

3.2.3 The Person Detection That We Used a Web Camera

This system detects the person by WEB camera. The image when the person comes in front of the shelf by using the Web camera set up in the ceiling of each item shelf is acquired (right of Fig.3), and processing that takes the difference with the background image (left of Fig.3) acquired beforehand is done [1]. SSS is able to acquire data adequately by updating the background image when data will not be sent from the Web camera in fixed time even if the environment changes. This system judges that there is a person in the place when the difference between the acquisition image and the background image is great, this system stores the data of acquisition time of observed image and the place of the item shelf in the data base named "CEILING" on SSS when there is a person, and leaves it as an observation log.

3.2.4 The Hand of the Person Who Used a Web Camera and the Detection of the Movement of the Item

In the experiment, this system detects person's hand and the movement of the item by using two WEB cameras.

First, this system acquires the image when feeling after the item of the shelf by using one the Web camera (touch camera) set up in each item shelf. The background image at this time is assumed to be a state that the item is put on the shelf (Fig.4). This system defines to feel after the item put on the item shelf when the difference between this acquisition image and background image is great, this system stores the data of acquisition time of observed image and the place of the item shelf in the database named "SHELF1" on SSS when there is a person's hand, and leaves it as an observation log. SSS is able to acquire data adequately by updating the background image when data will not be sent from the Web camera in fixed time even if the

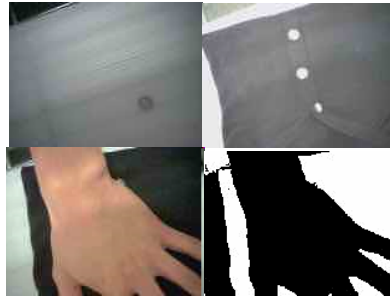


Fig. 4. Observation image and picture processing with shelf camera

environment changes. Second, this system acquires the image when the item of the shelf is being taken up by the consumer using another Web camera set up in each item shelf. At this time, the image from which the item is not put on the shelf is assumed to be a background image. The system assumes the item was taken by the consumer when there is no difference between the acquisition image and the background image, this system stores the data of acquisition time of observed image and the place of the item shelf in the database named "SHELF2" on SSS when there is no item, and leaves it as an observation log.

3.2.5 The Definition of the Action by the Observation History

We combine the observation histories left for each database of "RFID" "CEILING" "SHELF1" "SHELF2", and define the action to observe "See" "Touch" "Take" defined to make each action taken in the store an amount with RFID and Web camera (Table 3). First, this system assumes the state to see the item when the place of the shelf is corresponding to the observation time from the observation log of database "RFID" and "ceiling", and accumulates in the database named "SEE" as a behavior log. When the consumer was halting in front of the item shelf, we assumed the consumer would see the item. Moreover, this system assumes the state to feel after the item when the place of the item shelf is corresponding to the observation time from the observation log of database "RFID" "SHELF1", and accumulates in the database named "touch" as a behavior log. In addition, this system assumes the state taken up when "Take" is corresponding to the observation time the place of the item shelf from the observation log of database "RFID" "SHELF2".

3.3 A Precision Evaluation Experiment

We experimented the evaluation of accuracy to which is "See", "Touch", and "Take" were observed by using SSS. The experiment puts one T-shirt per one item shelf of SSS (six shelves in total) and five subjects freely see, touch, and take T-shirt, finally take up and choose one T-shirt taking. At this time, the subject takes some actions for all items. Moreover, we took a picture of all processes from the experiment beginning to the end with the fixed point video camera. The frequency of "See", "Touch", and "Take" that the system of SSS had obtained and the frequencies of "See", "Touch", and "Take" when seeing with the video camera with the unassisted eye were comparing verified, and the accuracy of SSS was evaluated. Table 1 shows the accuracy of the average of each subject of See, Touch, and Take.

Table 1. Result of accuracy evaluation of SSS

"See" Accuracy of observation	0.747
"Touch" Accuracy of observation	0.699
"Take" Accuracy of observation	0.633

3.4 The Evaluation Experiment of the Item in the Purchasing Space

We tested evaluation to examine utility of the technique that we described in section 2 with SSS. As for the item used this time, all are T-shirts or polo shirts (Figure 5) made by the UNIQLO company. The amount of the feature is squeezed to two (the color and the shape of the neck), each of white, the black, the pink color, yellow, light blue, and the navy blue six color crew necks (Thereafter, it is written C), V problems (Thereafter, it is written V), polo shirts (Thereafter, it is written P), and the sizes are united in M size, and all materials are united to cotton, and 18 pieces in total were prepared. These two are selected at random, and six experimental sets are prepared by three sets. At this time, the same color is not in single-unit. Moreover, everything is all united to a dry cloth, and only the kinds are the single-unit mother-of-pearls in M size and the material in six color six pieces and the sizes as for the border shirt (Thereafter, it is written T). Four in total experiment sets are prepared.

UNIT1 : C = 2, V = 2, P = 2, UNIT2 : C = 2, V = 2, P = 2

UNIT3 : C = 2, V = 2, P = 2, UNIT4 : T = 6

We arrange experiment UNIT 1 to each commodity shelf of SSS (A to F) at random, and SSS observes the action that the subject takes in each item while shopping. Experiment UNIT 2, 3, and 4 are similarly done. We announce to the subject before experiment: "Please choose one favorite clothes or more from among the experiment set prepared in each shelf in the experiment store", and we have the subject actually choose the commodity of the favor in SSS. When the subject chooses all commodities, the experiment is ended. We will present the chosen item free of charge later to make the subject choose the commodity really wanting it. Moreover, to know the reason for the action where the subject had gone to the item, we did the questionnaire survey immediately after the experiment.

The subject sees twenty-four clothes used this time directly three days after the end of the experiment, and puts 5-point scale on each item. The purpose of the reason done three days after the end of the experiment is to obtain subject's essential favor from the questionnaire the subject forgets the action by the experiment.



Fig. 5. Sample item used by experiment

Table 2. Distinction analysis result of presumption of favorite item

	All subjects	Comparison type	Noteworthy type
Distinction coming true rate (%)	57.5	58.0	59.3
Probability according to misjudgement (%)	40.4	37.7	39.2

We average the action frequency of "See", "Touch" and "Take" of the subject who observed it by SSS, and calculate decentralization by this experiment. And we classified twenty-eight subjects into two shopping patterns by assuming the average and decentralization to be a variable and using the cluster analysis. As a result, the people who cause the action are five people in the commodity often, and subjects who hardly rush into action to the item are twenty-three people among twenty-eight subjects. Here, we name the subject who causes the action to the items a "Comparison type", and name the subject who hardly rushes into action a "Noteworthy type".

Next, when the item that put the evaluation of 3 to 5 was made a item group that was the favor by the questionnaire, and the item of the evaluation of 1 and 2 was made a item group that was not the favor, we calculated the relevance ratio of the evaluation by the questionnaire and the evaluation by the observation by using the discriminant analysis. The distinction result after the subject is divided with "Noteworthy type" group and "Comparison type" group is matched, and the result is shown in Table 2. Thus, the distinction coming true rate after it classifies it before it classifies it is higher, and it is understood that the probability according to the misjudgement has lowered.

4 Consideration

4.1 Basic Performance

The accuracy of the observation of "See", "Touch", and "Take" became a result in which about 70 percent from the accuracy evaluation experiment result of SSS constructed with this research. Touch and Take are thought to be a fall of accuracy because of causing of it the mis-observation when the difference with the background image was taken in a white system because of white the color of the item shelf T-shirt put on the shelf though See, Touch, and Take were observed by using the image data processing by the background difference method. The image processing technique of the background difference method that uses the background image is improved, and the observation of the action with high accuracy and the pursuit of the meaning of the action will be examined with a new sensor in the future.

4.2 Utility of Classification Technique of Behavior Pattern

The ubiquitous shop space was constructed with RFID and Web camera that was an ubiquitous sensor, the consumer saw the item, it felt after the item, and the subject was classified into the shopping pattern "Noteworthy type" and "Comparison type" by observing three action of taking the item, and using the cluster analysis from the action frequency.

In addition, we measured the hitting ratio of the distinction of the item of the favor by using the discriminant analysis to examine the utility of the classification. As a result, when you compare time that was not classified with time when "Noteworthy type" and "Comparison type" were classified, Classifying it into "Noteworthy type" and "Comparison type" goes up and the hitting ratio goes up and the probability according to the misjudgement fell.

We understand that the person of "Comparison type" that took a lot of actions to the item tended to choose the item from the result of the questionnaire (end of a paper appendix) immediately after the experiment more careful; For example, they select the item that matches to clothes that they have most, They touch all items, and select the most favorite item and so on. Oppositely, the person of "Noteworthy type" that doesn't rush into action so much for the item judges a favorite item and the hated item from externals, and they tend to choose the item when they found the item wanted most.

It is thought that the action on the item tended to become few overall because the number of commodities is little, all commodities are recognized easily in the actual experiment, and it selected it easily. As a result, it is thought that the subject of "Noteworthy type" that is the purchaser pattern with a little action frequency increased.

5 Conclusion

In this paper, when we can predict the interest and the preference to the item from consumer's action log in the shop space, we paid attention to the existence of the behavior pattern by consumer's individual, and proposed the technique for presuming whether the item that caused the action liked it. In the experiment, we have tested twenty-eight subjects on twenty-four T-shirts, and we got better precision ratio for each subjects on estimating preference and favorite items by discriminate analysis on his or her behavior log, and behavior patterns classification above. Thus, it is thought that this technique has utility. We will improve the accuracy of SSS more in the future, and after understanding consumer's individual behavior pattern from this technique, the system that does recommend of the item guessed to be a favor by using Web a browser from the display set up in the store is constructed, and it aims at the construction of the algorithm to display recommend put together on the difference of the behavior pattern.

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