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MODELING OF HUMAN INTEREST IN PRODUCTS BY OBSERVING BEHAVIORS OF CUSTOMER IN A STORE

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ABSTRACT

This paper proposes a method for modeling the degree of human interest in products for sale by observing the behaviors of customers in a store. In this study, we observe human behaviors towards products in a ubiquitous environment and analyze the observed data using cluster analysis and rough sets to make a model of level of interest. We call our model the "Action Interest model." We confirm that the action interest model can measure the degree of human interest in a product, based on their behavior toward it, to an accuracy of 87%. It is also possible to detect the level of interest in a product in which a consumer shows interest but does not buy.

Keywords: *KANSEI modeling, analysis of consumer behavior, ubiquitous environment, rough set, cluster analysis*

1. INTRODUCTION

Our study attempts to estimate the degree of a person's interest in clothes or sundries in which the person takes an interest (hereinafter "products,") based on the difference in behaviors shown toward products, such as inspecting or touching them. In today's society, where people's senses of value are increasingly diverse, there is a growing number of mechanisms for predicting what kind of products people have an interest in, based on their purchase history, and using these predictions for marketing purposes or to make targeted recommendations. However, use of information based on purchase history leads to recommendations for products similar to those already owned, which tends to cause annoyance. New products that are developed based on purchase history are also likely to be much the same as those currently on the market. To address this problem, our study focuses

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on people's attitudes to products during the stages of their purchasing decision-making process and their interest in the products. Our study suggests that products toward which people show active behaviors, such as looking at them for a long time, picking them up or inspecting them in detail, may have special characteristics that attract their attention, making them more likely purchase this or similar products in the future.

Our research proposes a method of modeling the relationship between people's behaviors toward products and their interest in them as an "active interest model" by measuring people's behaviors toward products based on their interest during each stage of their purchase decision-making process in a ubiquitous environment equipped with sensors and cameras, conducting statistical and rough set analysis of the observed data and establishing rules from them.

2. MODELING OF THE RELATIONSHIP BETWEEN INTEREST AND BEHAVIORS

Philip Kotler, an American economist, notes that the state of people's minds as they intend to purchase products is divided into five stages, as shown in Table 1 [1].

In this decision-making process, the degree of people's interest in the product increases, and their behaviors toward the product become more active as the stages proceed. For example, people at the stage of "problem recognition" are not yet sure whether they have an interest in the product and therefore just look at it in most cases, without showing any active behavior it product such as picking it up and inspecting it in detail. On the other hand, people at the stage of "evaluation of alternatives" have already found a product that suits their interest, have actively touched it, picked it up, and inspected it in detail. People at the "purchase decision" stage know their evaluation is right and take the action of purchasing it.

Table 1: Philip Kotler's decision-making process

Stage	Stage Name	Description
1	Problem recognition	Stage where a person recognizes his need for a product
2	Information search	Stage where a person intends to obtain more information on a product
3	Evaluation of alternatives	Stage where a person evaluates a product based on the information acquired
4	Decision of purchase	Stage where a person decides to purchase the product based on his evaluation
5	Post-purchase behavior	Stage where a person evaluates the product he purchased

Our research focuses on the stages from problem recognition to evaluation of alternatives where people show behaviors toward products as described in Philip Kotler's decision-making process. We propose a model for estimating the degree of people's interest in a product based on their behavior toward it during those stages. The modeling algorithm proposed in our study consists of the following three procedures, each of which is explained in detail in the following sections.

1. Observation of people's behavior toward products using a ubiquitous environment
2. Classification of people's behaviors toward products
3. Formulation of a rule indicating the relationship between the degree of interest and the behavior

2.1. Observation of people's behaviors

People's behaviors toward products at the "information search" stage or "evaluation of alternatives" in the decision-making process include turning to products or other people such as looking for information on the Internet or asking the sales staff or friends. Our research confines the scope of such behaviors to those conducted only by an individual alone, without using tools or asking other people, such as "looking at the product," "touching the product," or "picking up the product."

Table 2: Interpretation of people's behavior in our study

Behavior	Interpretation in our study
Looking at	A sensor installed in front of a product observes the presence of a person for a certain period of time
Touching	A sensor installed in front of a product observes the presence of a person, another sensor installed near the product observes any change in the product's position, and the observation time of the person matches the change time of the product for a certain period of time.
Picking up	A sensor installed in front of a product observes the presence of a person, another sensor installed near the product observes the change in the position of the product, and the observation time of the person matches the time of the disappearance of the product for a certain period of time.

In our study, based on the procedure shown in Figure 1, we observe people's behaviors using the Smart Sphere System (SSS) [3] fitted with cameras and sensors such as RFID (radio frequency identification). SSS is the ubiquitous environment developed by the authors. We then identify the behaviors of "looking at the product," "touching the product" and "picking up the product" from the observation results according to the definitions in Table 2 and quantify them. Although Figure 1 only shows the procedures related to "touching" due to limits on space, we can use the same identification for "inspecting" and "picking them up" employing the same technique, simply by changing the type or number of sensors.

The first step is to observe, at selected locations where the camera or RFID is installed, the behaviors of people or any changes in their behaviors at each point and the time when such change occurred. For the example in Figure 1, SSS reads the information of the RFID card held by a person using RFID X and observes the reaction time of the person's ID and RFID card. SSS also observes any change in Product a and the time that the change occurred, using camera Y.

The second step is to store the measured data in the logged database connected to the sensors. The logged database has information to show what product is placed at what point.

Using this information, SSS relates the relationship between people's behaviors and the products based on the location information and the observation time information. For the example in Figure1, since the information that Product a is located at Point A is owned by SSS, and the time when Person 1 is recognized at Point A matches the time when Product a located at Point A changes, SSS relates Person 1 to Product a.

The third step is to identify the types of behaviors toward products based on the logged data where people and products are related to each other according to the interpretation of people's behaviors shown in Table 2. For the example in Figure 1, the behavior of "touching" is defined as "the time of a product change in position matching the observation time of a person at a certain location for a certain period of time (= 10 seconds)." Based on this definition, the information on the behavior of "Person 1 touching Product a at Location A for 15 seconds" is derived from the logged data.

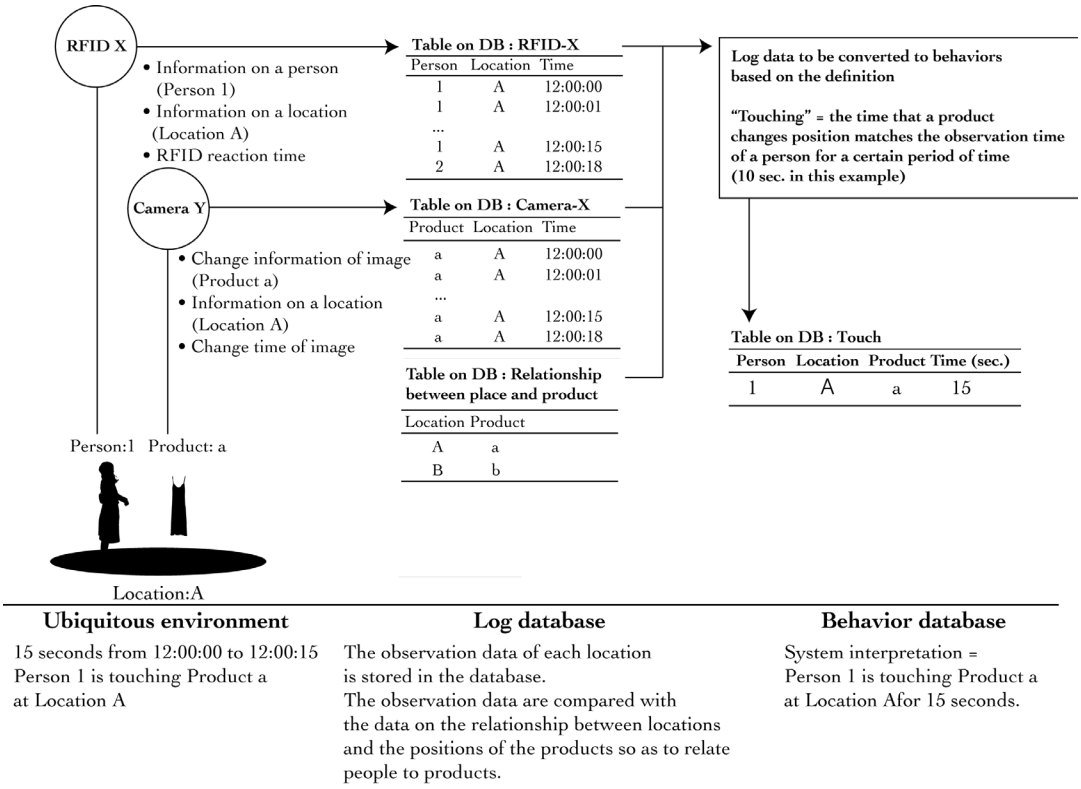

Figure 1: Quantification of people's behaviors toward products using the ubiquitous environment (case where Person 1 is looking at Product a at Location A)

2.2. Classification of people's behaviors toward products

In our study, it is assumed that the difference among the three kinds of people's behaviors: "looking at," "touching," and "picking up," toward products at the stages of "problem recognition," "information search" and "evaluation of alternatives" in the decision-making process can be expressed by the proportion of time taken for each of these three behaviors toward products. For instance, a person at the evaluation stage, who has already found a product that suits his interest, thinks he wants to check the product in detail. Therefore, it is speculated that a person at the evaluation stage shows the behavior of "picking up," which he

does as he checks it in detail, more frequently than the other behaviors of "looking at" and "touching." Thus, it is assumed that the high interest in the product marks the evaluation stage. On the other hand, a person at the information search stage is looking for a product that can match his interest and therefore shows such behavior as looking at and touching more than one product.

Therefore, when the behaviors of people at the information search stage are represented by the three behaviors of "looking at," "touching," and "picking up," the behavior of "picking up," which is part of the process of careful checking, is considered to less common than "looking at" or "touching," which is shown while gathering of information. Therefore, the degree of people's interest in a product that causes the behavior considered to be at the information search stage is assumed to be lower than that at the evaluation stage. Whereas people at the stage of "problem recognition" have not yet found products that satisfy their interest or have not encountered products that might satisfy them, it is assumed that they just a glance at products and do not show active behaviors such as touching or picking them up.

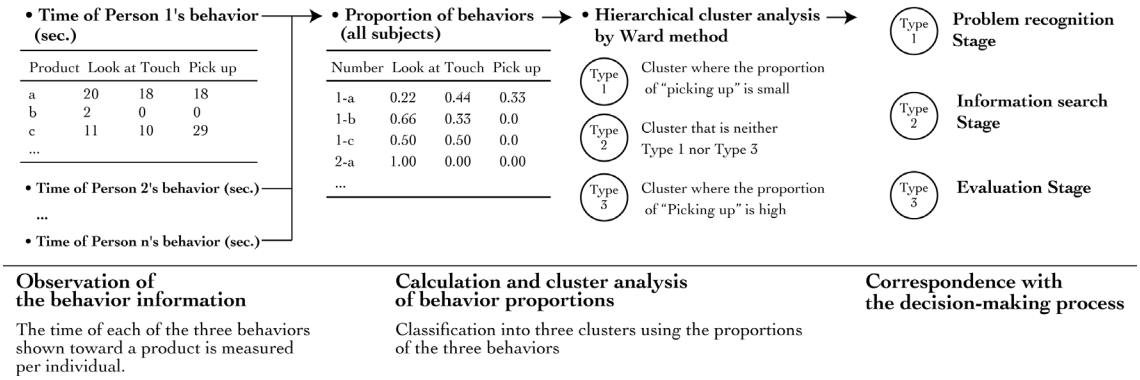

Figure 2: Algorithm for converting people's decision-making process into people's behaviors toward products

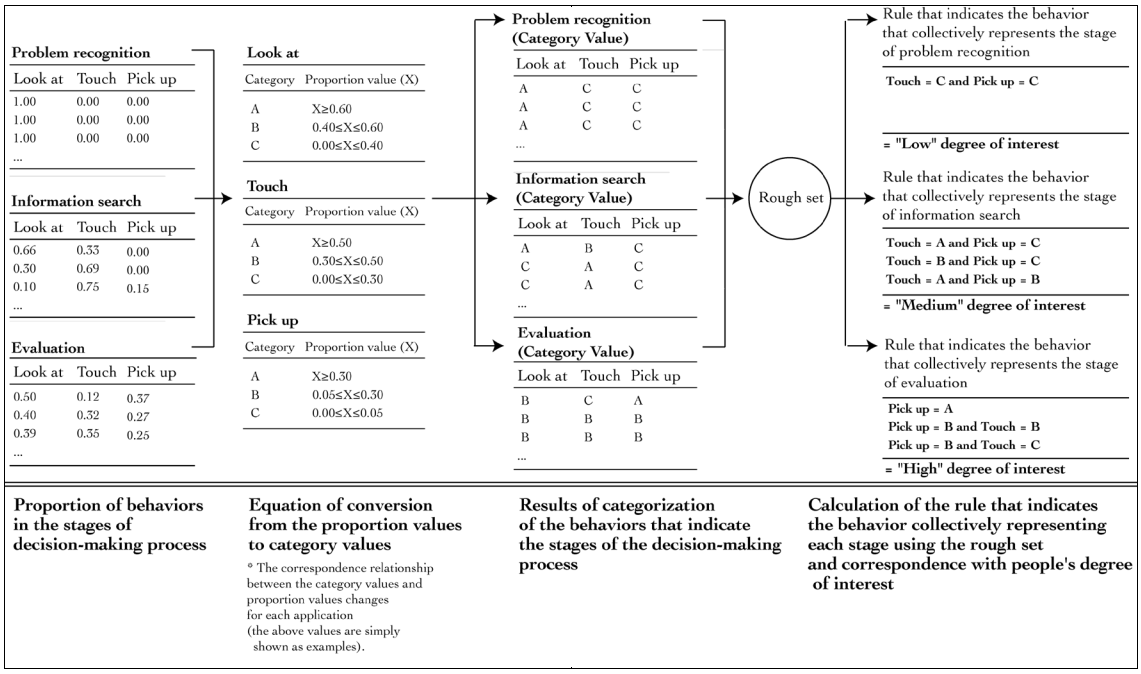

Figure 3: Algorithm that formulates the active interest rule that shows the relationship between people's behaviors and their interest

Thus, the proportion of behaviors such as "touching," or "picking up" at the problem recognition stage is considered to be almost zero or at least lower than in other stages. The degree of interest in a product that causes behaviors considered to be at the problem recognition stage is assumed to be lower than in the above two other behaviors.

Based on the above assumptions, our study uses the algorithm shown in Figure 2 and relates people's behaviors to "problem recognition," "information search" and "evaluation of alternatives." The algorithm used here observes the length of time an individual shows the behaviors of "looking at," "touching," and "picking up" for each product and then converts the observation data into the proportion data according to the following equation.

$$Looking\_at_A : Touching_A : Picking\_up_A = \frac{Looking\_at_{Asum}}{All_{Asum}} : \frac{Touching_{Asum}}{All_{Asum}} : \frac{Picking\_up_{Asum}}{All_{Asum}}$$

$Looking\_at_{Asum}$: total length of time a person spends looking at Product A

$Touching_{Asum}$: total length of time a person spends touching Product A

$Picking\_up_{Asum}$: total length of time a person spends examining Product A after picking it up

All_{Asum}: total length of time a person spends on all behaviors (total of $Looking\_at_{Asum}$, $Touching_{Asum}$ and $Picking\_up_{Asum}$)

Table 3: Correspondence between each decision-making stage and people's behaviors toward products

Stage of decision-making	People's degree of interest	Cluster analysis of people's behaviors toward products
Evaluation	High	Cluster where the average proportion of "picking up" is higher than those of the other two
Information search	Medium	Cluster where the average proportion of "picking up" is higher than that of problem recognition and lower than evaluation
Problem recognition	Low	Cluster where the average proportion of "picking up" is lower than those of the other two

The last operation in our study is hierarchical cluster analysis using the Ward method, in which the proportion of the length of time of each of the three behaviors is classified into three clusters as descriptive variables. The relationship between the three clusters and the stages of the decision-making process is explained in Table 3, where the said relationship is clarified by focusing on "picking up," a behavior that is likely to be predominant among the three stages.

2.3. Formulation of the rule indicating the relationship between the degree of interest and behaviors

To derive the degree of people's interest in a product from their behavior toward it, the rule indicating the relationship between the behaviors and the degree of interest (hereinafter the active interest rule) is formulated using rough set [4]. Figure 3 shows the result of an example of processing according to the algorithm that formulates the active interest rule.

The first step in deriving the active interest rule is to convert the proportion values of the three clusters connected to the stages of decision-making into category data to allow them to be treated in the rough set. In our study, the proportion values are divided into three categories, A, B and C, the range of each of which is determined as follows.

1. The average of the proportions of the behaviors (looking at, touching and picking up) should be calculated for each category.
2. For each behavior, the value of the average over the proportions of the stages rounded to two decimal places should be compared for each behavior. Depending on the size of the result, a value equal to or greater than the intermediate should be defined as A, equal to or greater than the minimum and smaller than the intermediate as B, and smaller than the minimum as C.

For example, if the average of the proportions of the stages for "looking at" is 1.000 for problem recognition, 0.515 for information search, and 0.375 for evaluation, the intermediate and minimum will be 0.515 and 0.375, respectively. Therefore, each value is rounded off to two decimal places to set the range of each category to 0.52 or higher for A, 0.38 or higher and below 0.52 for B and below 0.38 for C.

The second step is to analyze the categorized proportion data of behaviors for each stage in terms of the rough set [4] and calculate the rule that collectively represents the behaviors of each stage. Figure 3 shows that the range of behavior category of the people considered to be at the problem recognition stage is "C for touching" and "C for picking up" according to rough set analysis. This indicates that the people at the problem recognition stage "spend less time touching or picking them up."

The third step is to formulate a rule that derives the degree of people's interest in a product based on their behaviors toward the product by matching the rule developed by the rough set, as per Table 3, to the degree of people's interest. Take Figure 3 as an example. An active interest rule can be developed in which "the degree of interest is low when 'looking at' is C and 'picking up' is C".

3. THE EVALUATION EXPERIMENT OF THE MODEL AND ITS EVALUATION

Our study evaluated the precision of the "active interest rule" by using the results of the observation experiments of people's behaviors conducted by the authors as reported in Reference 3.

In the experiment in Reference 3, a mock clothes shop, equipped with SSS, was set up in the laboratory, and 12 kinds of UNIQLO T-shirts, each of differing color and collar design, were placed on six display shelves, with two shirts side by side per shelf. Thirteen male subjects, all in their 20s, were instructed to enter the mock store one by one and were given the task of taking the shirt they wanted to the checkout counter. Their behaviors toward the T-shirts were then observed. In this experiment, the set of T-shirts was changed twice, with the subjects each time going through the same process again. After the experiment, the

subjects were given a questionnaire survey on their degree of interest in a total of 24 kinds of shirts for evaluation on a scale of one to five.

Table 4: Extract of the results of cluster analysis after the behaviors of 13 subjects were converted to the ratio data

Stage: Evaluation				Stage: Information search				Stage: Problem recognition			
Number	**Look at**	**Touch**	**Pick up**	**Number**	**Look at**	**Touch**	**Pick up**	**Number**	**Look at**	**Touch**	**Pick up**
5	0.39	0.30	0.30	1	0.50	0.50	0.00	0	1.00	0.00	0.00
65	0.46	0.37	0.17	11	0.67	0.33	0.00	2	1.00	0.00	0.00
126	0.44	0.35	0.21	14	0.50	0.50	0.00	3	1.00	0.00	0.00

To ensure the integrity of the data for evaluation of precision of the active interest rule used in our study, all the behaviors of the 13 subjects toward the 12 kinds of T-shirts observed with SSS as in Reference 3 were checked using a verification video camera; and any behavior that was missed by SSS was covered by additional data acquired to compensate for the missing data, to ensure that the observation precision of SSS would be sufficient to compile an accurate active interest rule.

Table 4 shows part of the cluster analysis results of the subjects' behaviors. To be specific, a total of 312 pieces of data that recorded the 13 subjects' behaviors toward the 24 kinds of T-shirts in the two experiments were converted to proportional data according to the algorithm that classifies people's behaviors toward the products, as explained in 2.2; and 10% of the data, or 31 items, were removed at random from the data for evaluation. The remaining 281 items of data were subjected to hierarchical cluster analysis using the Ward method of classification. An extract of the analysis results is shown in this Table. The relationship between the clusters divided into three categories and the five stages of the decision-making process are determined by the value of the "Picking up" proportion, as shown in Table 3.

To identify the behaviors that represent each stage of the decision-making process by rough sets, the mean and standard deviation of each cluster, which serves as the basis for converting the behavior proportion data into the category data, and the ranges of categories derived therefrom, are shown in Table 5. Based on Table 5, the behavior data for each stage were categorized, and the resultant data are analyzed by rough sets as shown in Table 6.

The precision of the active interest rule shown in Table 6 was evaluated by the "behavior proportion data" using the 31 items of evaluation data, the evaluation by the questionnaire, and the estimated values and match rate according to the active interest rule, as shown in Table 7. For the questionnaire survey results used for this evaluation, the results on a scale of one to five were converted to a scale of one to three so as to match the degree of interest of the decision-making process. Specifically, Grades 1 and 2 on a scale of one to five were merged to match Grade 1 in the degree of interest, Grade 3 was set as Grade 2 for degree of interest, and Grade 4 and 5 were merged to match Grade 3 for degree of interest.

Table 5: The mean and standard deviation of the proportions of the behaviors in each stage of decision-making process (top table) and the category ranges for conversion of the behavior proportion data into category data (bottom table)

Stages of the decision-making process	Behavior	Mean	Standard deviation
Problem recognition	Look at	1.00	0.00
	Touch	0.00	0.00
	Pick up	0.00	0.00
Information search	Look at	0.53	0.14
	Touch	0.47	0.11
	Pick up	0.01	0.04
Evaluation	Look at	0.38	0.09
	Touch	0.33	0.07
	Pick up	0.30	0.09

Behavior	A	B	C
Look at	$0.52 \leq X$	$0.38 \leq X < 0.52$	$X \leq 0.38$
Touch	$0.47 \leq X$	$0.33 \leq X < 0.47$	$X \leq 0.33$
Pick up	$0.30 \leq X$	$0.01 \leq X < 0.30$	$X \leq 0.01$

When the evaluation data were classified into the three stages of the decision-making process by the active interest rule, the match rate turned out to be 0.87. This indicates that the active interest rule is capable of estimating each stage of the decision-making process.

Table 6: Action interest rule that shows the relationship between behaviors and interest

Problem recognition Degree of interest (low)	Information search Degree of interest (medium)	Evaluation Degree of interest (high)
Touch = C and Pick up = C	Touch = A and Pick up = C	Pick up = A
	Touch = B and Pick up = C	Pick up = B and Touch = C
	Touch = A and Pick up = B	Pick up = B and Touch = B

On the other hand, the rate of matching between the questionnaire results, converted to a scale of one to three, and the estimation results by the active interest rule were a very poor 0.52. To analyze the cause, the numbers of the data that failed to match the active interest rule were checked using the verification video camera. It was found that the subjects did not show any behavior toward the T-shirts with the data numbers that didn't match the active interest rule in the mock store. Whereas the subjects saw the products for a certain length of time and evaluated them according to their response to the questionnaire. It is therefore speculated that their evaluation in the store where they made an instant evaluation while moving turned out to be different from the evaluation they made seated, looking at the display while they answered the questionnaire. It is necessary to review the method of

comparing a subject's degree of interest based on his behavior with his degree of interest reported in his questionnaire responses.

Table 7: Results of the evaluation data assessed by the action interest rule

Data no.	Look at	Touch	Pick up	Decision-making	Evaluation	Stage estimated by the action interest rule	Comparison with the three stage evaluation Match rate: 0.52	Comparison with the decision-making stages Match rate: 0.87
166	A	C	C	1	3(2)	1	0	1
190	B	B	C	2	3(2)	2	1	1
207	A	B	C	2	3(2)	2	1	1

• Stages of the decision-making process
1: Problem recognition, 2: Information search, 3: Evaluation
• Parenthesized numbers in this evaluation are those converted from a scale of five to a scale of three
1: Grade 1 to 2 of a scale of five, 2: Grade 3 of a scale of five, 3: Grade 4 and 5 of a scale of five
• For the comparison between the questionnaire survey result and the decision-making stages:
1 indicates appropriate, while zero inappropriate.

4. CONCLUSION

In this paper, we proposed an algorithm that establishes an active interest rule which calculates people's degree of interest in a product on a scale of one to three based on their basic behaviors toward the product due to their interest in it, namely "looking at it," "touching it" and "picking it up." The proposed algorithm has the following two characteristics:

- It allows estimation of people's degree of interest based on their behaviors they show alone without turning to others or tools, namely "looking at it," "touching it" and "picking it up."
- It allows estimation of people's degree of interest in products during the three stages of the decision-making process before a purchase: problem recognition, information search and evaluation, which cannot be estimated from purchase history, which only shows the end results of purchases and whether or not the consumer purchased the item.

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