A Novel Personalized Recommendation Method in E-business Based on Kansei Image

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Abstract. Personalized recommendation technique is an important technology to solve information overloaded in e-commerce. But recently new commodities are emerging constantly, so it is required to recommend commodities that consumers aren't familiar with but interested in. Consequently our study proposes a method to mine consumer's preference from the respective of consumer psychology. Consumers' affective needs can be described in the form of kansei image preference and kansei image weight. Then recommendation results are produced to meet consumer's quantitative affective needs. Finally by real historical data of 15 consumers online and surveys in the example of garments, validity of the method is verified.

Introduction

Nowadays information overloaded is becoming a major challenge faced by e-commerce. In order to solve the problem, personalized recommendation system is introduced and regarded as one of the most effective tools[1], which is defined to help consumers to make decisions based on recommendations by other individuals or authorities[2].

But with the emerging of new commodities, some problems have arisen, such as low utilization of consumer information, instable recommendation lists and weak timeliness[3-5], posing new challenges to recommendation systems. On basis of consumer psychology, consumers' purchasing behavior is decided by consumer psychology[6], that is to say, consumer psychology is the root cause of consumer preference. If consumer psychology is introduced into personalized recommendation, it is possible to provide more precise recommendation results.

Kansei image is a consumer-oriented concept, and it is the psychological sensation to a product from consumers' cognition of emotion[7], reflecting a consumer's affective need. Based on the concept of kansei image we propose a recommendation method to mine the consumer's preference from commoditiesin historical data(commodity information in order, shopping cart and browsing history). Combined with fuzzy theory, we can locate the consumer's internal affective need and produce precise recommendation results.

The paper is organized as follows. The next section we present the description methods of kansei image and commodities, and establish quantitative reflection between them. Affective need analysis and personalized recommendation methods are proposed. Then recommendation results are verified in the example of garments. Finally we conclude the paper.

Reflection between kansei images and commodities

Description of kansei images. Kansei images are depicted as sets of kansei words $K=\left\{k_i \middle| i=1,\cdots,N\right\}$ where k_i values [-1,1].Values of k_i only reflect the consumer's psychological preference without positive or negative meanings. Let's illustrate the model with the example of word-pair "mature-young".

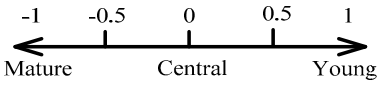

Fig.1 Description of "mature-young"

From Fig.1 we can see that positive numbers of k_i stand for "young", negative for "mature". What's more, smaller values represent more mature and vice versa. So kansei images for a commodity can be described with a vector comprising of k_i .ranging from -1 to 1.

Description of commodities. According to the theory of morphological analyses, objective and recognizable commodity features are used to indicate commodities. Each commodity can be regarded as the organic combination of different commodity features, so it can be represented in the form of $F=(f_1,f_2,\cdots,f_m)$,where f_i stands for the i^{th} feature of the commodity, valuing $\{0,1\}$.

Building of reflection between kansei images and commodities. Based on opposite adjectives, numerical scare of seven-grade serial numbers is used to evaluate kansei images with semantic differential method[8]. For example, to the word pairs 'mature-young', experts rate concepts against the series of seven-point scales: extreme mature, very mature, normal mature, central, normal young, very young, extreme young. Then the linguistic descriptions are quantified with correspondent triangular fuzzy numbers (0,0,0.1,), (0,0.1,0.3), (0.1,0.3,0.5), (0.3,0.5,0.7), (0.5,0.7,0.9), (0.7,0.9,1.0), (0.9,1.0,1.0) as in Fig.2.

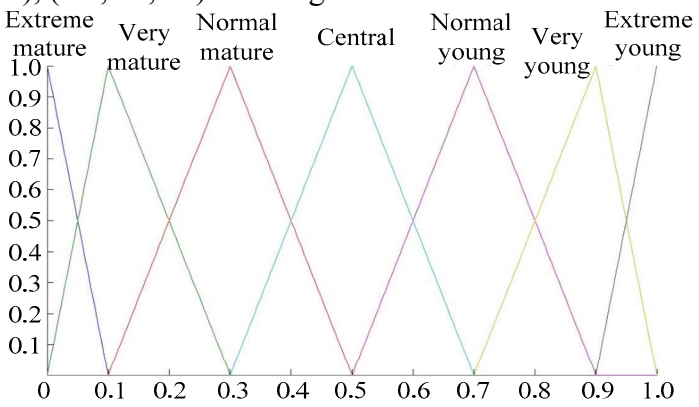

Fig.2 Fuzzy member function diagram of linguistic description

After statistical calculation, the numbers of experts choosing seven-grade serial numbersare recorded and respectively represented by $n_{ij1},\cdots,n_{ij7}$. So the reflection can be represented by triangular fuzzy number asin equation(1).

$$\tilde{r}_{ij}=\left(\frac{1}{n}\sum_{l=1}^{7}\left(r_{l1}\cdot n_{ijl}\right),\frac{1}{n}\sum_{l=1}^{7}\left(r_{l2}\cdot n_{ijl}\right),\frac{1}{n}\sum_{l=1}^{7}\left(r_{l3}\cdot n_{ijl}\right)\right) \tag{1}$$

Then we utilized the method of maximizing set and minimizing set[9] to calculate the total utility as in equation(2). Finally reflections could be represented in the form of $m\times n$ fuzzy relation matrix.

$$u_T(i)=\left[\frac{c_i-x_{\min}}{(x_{\max}-x_{\min})-(b_i-c_i)}+1-\frac{x_{\max}-a_i}{(x_{\max}-x_{\min})+(b_i-a_i)}\right] \tag{2}$$

Recommendation method

Analysis of the consumer's affective need. A consumer's affective need is relatively stable, so by analyzing consumer's historical data, we can get a consumer's individual affective need. In our study, consumer's affective need is analyzed in two aspects, including kansei image preference and kansei image weight. Kansei image preference is consumer's choice in a pair of words from the horizontal point of view, such as 'mature' instead of 'young'; while kansei image weight is balanced from the longitudinal aspect, and for instance, it means that compared with 'mature' in the

word-pair ‘mature-young’, the consumer prefers ‘formal’ in the word-pair ‘formal-casual’.

Kansei image preference. To acquire consumer’s personalized preference for kansei image, the following steps are performed.

Step 1) Weassume that customers online purchase a commodity in three sequential steps[10], so we can classify products in historical data into three classifications including commodities in an order, in shopping cart and in browsing history as shown in Fig3. The levels that different classifications reflect consumer’s affective need are different. According to the IS-A relation between different classifications, weights we give them are respectively 4,2,1.

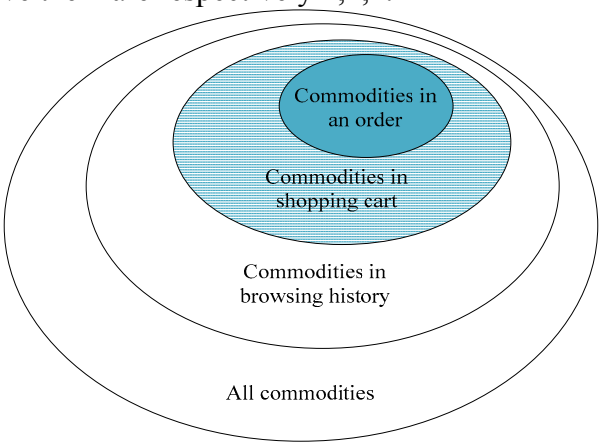

Fig.3 Commodity classification according to the customer’s shopping steps

Step 2) Extracted commodities are processed with the method of commodity feature space. Then all the commodities in the consumer’s historical data are depicted as $F=(F_1,F_2,\cdots F_t)^T$,where F_i is the commodity in historical data.

Step 3) Kansei image rating matrix is built. With $m\times n$ fuzzy relation matrix in equation(4), wecan get the kansei image rating matrix, and it reveals consumer’s overall preference for kansei images.

Step 4) The kansei image preference is calculated as in equation(3). Then it is standardized to ranging from -1 to 1.

$$q_j=\sum_{i=1}^{t}\xi_i k_{ij}\Big/\sum_{i=1}^{t}\xi_i \tag{3}$$

$$p_j=2q_j-1 \tag{4}$$

where ξ_j=4 when the commodity is in order; ξ_j=2 when the commodity is in the shopping cart; ξ_j =1 when the commodity is in the browsing history.

Finally, we gained the consumer’s personalized kansei image preferencein the form of $P=(p_1,\cdots,p_N)$, and the value of p_j conveys the consumer’s preference information for the j^{th} word-pair.

Kansei image weight. Consumer’s affective need is relatively stable, so a consumer’s preference for kansei image also should be stable theoretically. But in the real situation, ratings data in the same kansei image for the particular consumer also vary from commodities to commodities, which is caused by the balance between different kansei images, that is to say, some kansei imagesare more important than the others for a consumer.

So we put forward the concept of kansei image weight. More stable ratings indicate more important kansei images, corresponding to larger kansei image weights. In this principle, weights of kansei image for a consumer W are calculated according to equation(5)-(7).

$$W=(\omega_1,\cdots\omega_N) \tag{5}$$

$$\omega_i=\ln\sigma_i\Big/\sum_{i=1}^{N}\ln\sigma_i \tag{6}$$

$$\sigma_i = \sqrt{\frac{1}{t}\sum_{j=1}^{t} \xi_j \cdot \left(x_{ij} - \frac{1}{t}\sum_{j=1}^{t} x_{ij} \cdot \xi_j \right)^2} \tag{7}$$

where ω_i stands for weight of kansei image k_i; σ_i is our modified standard deviation and it indicates the differences of ratings.

In summary, based on kansei image preference and kansei image weight, a consumer's affective need model is constructed as in equation(8).

$$A = p_1/\omega_1 + p_2/\omega_2 + \cdots + p_N/\omega_N \tag{8}$$

where the symbol "/" links the preference and weight of the kansei image, and the symbol "+" shows that the various p_i/ω_i collectively comprise the sets.

Recommendation degree calculation. Since a customer's affective need can be interpreted as the customer's expected utility measured based on the customer's perceived benefits embodied in a combination of kansei words[11], our proposed method follows the principle that the more a commodity satisfies a consumer's affective need, the greater possibility that the consumer will purchase it. Finally a personalized shopping list can be suggested based on the customer's particular affective need.

Considering dual attributes of affective need, consisting of kansei image preference and kansei image weight, our study utilized Hamming similar approach degree to calculate the recommended degree of commodities as in equation(9). Finally commodities whose recommended degree greater than a defined threshold value are recommended to the consumer.

$$R = 1 - \sum_{i=1}^{5} \omega_i \left| p_i - x_i \right| \tag{9}$$

Example verification

Date preparation. We focus on garments in e-commerce to recommend with the proposed method. According to three main design elements of garments, twenty six features are extracted and each commodity is transferred into a 27-dimensional vector comprising of zero and one. Five word-pairs meaning kansei images are extracted and chosen from 110 adjectives investigated forming kansei image space as in Table.1; Then fuzzy relation matrix is built according to equation(1)(2) based on appraisals of 20 experts towards commodity feature space and kansei image space and it is the foundation of analysis of affective need.

Table.1 Kansei image space and its definition

No.	Kansei word in pairs	Definition
1	Mature-Young	Age orientation
2	Unique-Usual	Individuation orientation
3	Formal-Informal	Occasion orientation
4	Male-Female	Gender orientation
5	Fashionable-Traditional	Tide-accepting consciousness

Our research is based on 15 online consumers' historical data. Let's take the consumer A as an example to illustrate. The data in the study is collected from September, 2014 to December, 2014 and each is labeled by categories, such as order, shopping cart or browsing history so that weights can be provided to commodities. After being preprocessed, the consumer's historical data are described in the form of commodity feature space.

Analysis of the consumer's affective need. With the method in section 3.1, the consumer's personalized affective need is calculated and depicted as in Fig.4.

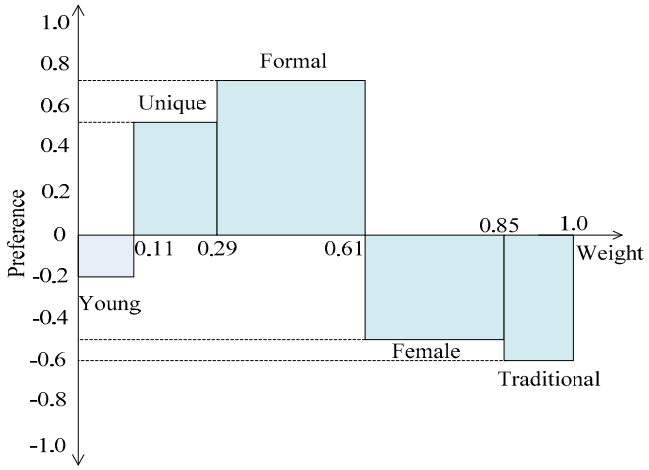

Fig.4 The graph of a consumer's affective need

The height of rectangles stands for kansei image preference. Take an example, the rectangle standing for "formal-casual" is over the line, and it indicates that compared with "formal" the consumer prefer "casual". What's more, the height of "formal-casual" is bigger than the one of "unique-usual", so the degrees of preference are different. Precise numbers can precisely reflect the consumer's personalized preference. In addition, widths of rectangles indicates weights of respective kansei image. The rectangle indicating "formal-casual" is the widest and it means the consumer care whether it is "formal" or "casual" the most. Importance of other kansei images diminishes according to the width of rectangles. And we can conclude that the top three kinds of kansei image are emphasized primarily, respectively "formal-casual", "male-female", "unique-usual". As for the left ones, the consumer doesn't pay too much attention.

In summary, we can conclude that the consumer prefer garments with very casual, vary male and normal usual kansei images, and weights of the three kinds of kansei image account for more than 70%. About whether the garment is fashionable or traditional, mature or young, the consumer cares less.

Recommendation results and verification. Using consumers' affective needs information we make recommendations forthem. Ordered by recommendation degrees calculated with equation(9), commodities whose recommendation degree greater than 0.85 are added into their recommendation lists among 50 typical commodities.

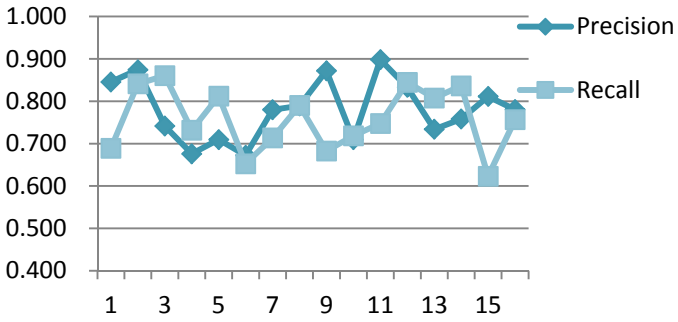

Fig.5 Precisions and recalls of our proposed method

To evaluate the rationality of recommendation results, 15 consumers in the survey are shown all the 50 commodities and asked to make a choice about whether to buy or not. Precision and recall are used as results verification measures in the research. As shown in Fig.5, precisions of most consumers are above 0.7 and the average is 0.780;recalls of most consumers are greater than 0.65, the average 0.757. It indicates that our recommendation results can greatly support consumers' affective needs, So the recommendation results are satisfactory.

Conclusion and future work

Concerning the issue that traditional recommendations only focus on the relevant relationships between historical and future purchasing behavior but ignore the internal cause, our study proposes a recommendation method from perspective of consumer's affective need. With the concept of kansei image, consumer's affective need can be dug and analyzed from the historical data and be used in personalized recommendation.

Objectively our study contributes to the application of consumer psychology in e-commerce, and it is a new insight into personalized recommendation. What's more, by extending kansei image space and commodity feature space, our proposed method can be easily applied to other commodities in e-commerce besides garments.

But only the affective need was discussed in our study because of the complexity of consumer psychology. In our future work, more aspects of consumer psychology could be studied in more commodities.

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