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Fashion Outfit Planning on E-Shopping Sites Considering Accordance to and Deviation from Policy

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Abstract: **It is difficult for users to look for garments they want to purchase on e-shopping sites because so many garments are sold there. We propose a system which inclines users to purchase garments recommended on the e-shopping sites, assisting the user to change her image within her fashion policy. This paper provides a recommendation system tailored to each user. It has paid attention to garments the user already has and outfits the user owns. The proposed method aims to recommend a garment which satisfies the following two requirements. The first requirement is to accord to user policies. The second is to change the image of the user. From an experiment, it is proved that 90% of recommended outfits matching the above requirements motivates examinees to purchase them. In addition, the method has recommended outfits that satisfy both of the two requirements with 35% of the precision.**

Keywords: **Recommendation, Outfit, Using Policy, E-Shopping Site**

1. INTRODUCTION

Currently, more and more users purchase garments on e-shopping sites[1].However, it is difficult for users to look for garments they want to purchase on e-shopping sites because so many garments are sold there.Users want a system which recommends garments they want to purchase on the e-shopping sites. To that end, it is necessary to recommend garments promoting the purchasing will of users.

Users have the policy for outfits. They have high tendency to purchase garments which satisfy their own policies as well as bring novelty to them. More precisely, it is assumed that a garment which satisfies the following two requirements caninclineusers to purchase them. The first requirement is to be easy to combine with garments that the user usually wears. The second is to give people around an impression different from the conventional ones.

In this paper, we propose a method to recommend the outfit which includes features lacking in usual garments of the useron e-shopping sites, while the outfit still goes well with the user policy. In the method, first, garments a user already has are divided into clusters which match the preference of each user. From each of the clusters, the method extracts the upper garment which plays a pivot role. Next, a method finds an upper garment which has little different characteristics from the extracted tops. The method combines it with lower garments the user wearswiththe extracted upper garment as outfits. Whenthe method recommends the outfits for users,the method asks user's opinion for those outfits as a feedback to improve recommendation quality.We have implemented a recommendation system based on the method. The system repeats recommendation, receiving user feedbacks. An experiment using the recommendation system has revealed the proposed method can recommend an outfit that avoids great deviation from user policies as well as increases the variety of the available outfits of users, which enhances purchase motivation of users.

2. RECOMMENDATIONS TO ENHANCE USER PURCHASE MOTIVATION

A. Garments users want to purchase

We assume that garmentsusers want to purchase must satisfy the following two requirements.

Condition 1: They accord to user policies.

Usually, users purchase garments matching their own preferences, making them look nice, or corresponding to their own policies. In this paper, a *policy* means particular preferences for garments of each user,such as color, texture, and style, and so on.

Condition 2: They change user image

When users get tired of their garments or their outfits, they will purchase new garments. This means that most users want to wear new outfits different from their conventional ones. Moreover, users want to increase the variety of their outfits by the combination of the new garments with ones they have. The paper regards an *image change* of a user as forming an outfitwhich provides people around with an imagedifferent from the one that they have held for her.

Here, let us consider a situation where users want to purchase new garments.

If users only consider Condition1 after all, they will purchase garments coming with characteristics similar to the ones they already have. Consequently, Condition 2 is not satisfied because they can only choose garments to coordinate the outfit such that they usually wear.

On the other hand, if users only consider condition 2, it would lead them to purchase garments which greatly deviate from their policies. In such a case, they cannot coordinate the new garment well with garments they have. Since garments users already have are based on their policies. They cannot increase the variety oftheir outfits.

From the consideration above, an outfit that accord to user policies as well as increase the variety of their outfits is useful to enhance their purchase motivation. The paper refers to an outfit which satisfies both Condition 1 and Condition2 as a purchase candidate outfit.

B. Related work

There are some e-shopping sites selling garments (e.g. ZOZOTOWN [2] and MYHABIT [3]). In these e-shopping sites, garments and outfits are recommended in a uniform manner from a point of popularity and a vogue. In other words, the garments which reflect no intention of users are displayed. Outfits in those e-shopping sites are far from ones according to their policies or matching their preference. It is difficult for users to purchase garments in these e-shopping sites.

There are researches of the outfit recommendation systems [4]-[7].

The method in [4] increases the variety of outfitswith garments a user has based on a user policy graph.The method in [5] allows users to choose and coordinate garments a user has, and gives a realistic impression by showing pictures of the user actually wearing them.However, the method in [4] and [5] uses only garments a user already has to increase the variety of the outfits. It cannot satisfy Condition 2 explained in section 2.1.

The work explained in [6] digitizes the preferences of users using garment characteristic such as design and silhouette by AHP method. It recommends a set of garments having high probability of purchase at the same time. However, the work does not consider bringing user imagechange with the recommended garments. They cannot satisfy Condition 2 insection 2.1.

The method in [7] recommends the outfits, using a support vector regression to classify garment images including clothing type, color, and appearance. . However, the method considers only upper garments. In such a case, users cannot coordinate the new garment well with garments they have.

3. Garment Recommendations To Balance Image Change With Policy

A. Recommendation method of purchase candidate outfits

This section proposes a method to recommend purchase candidate outfits.

We can assume that the user policy is reflected with the garments she already has, because she should have obtained garments matching her own policy. The analysis of the outfit logs of the user reveals characteristics to satisfy Condition 1.

Users change outfits, depending on time, occasion, and place (TOP) [8]. Fig. 1 shows an example of the outfits a user usually wears. The user wears casual outfits of a bright color with many decorations when she goes shopping or eats out. On the other hand, she wears formal outfits of dark color when she goes for work in in her Office. Similar to her cases, characteristics of the outfits

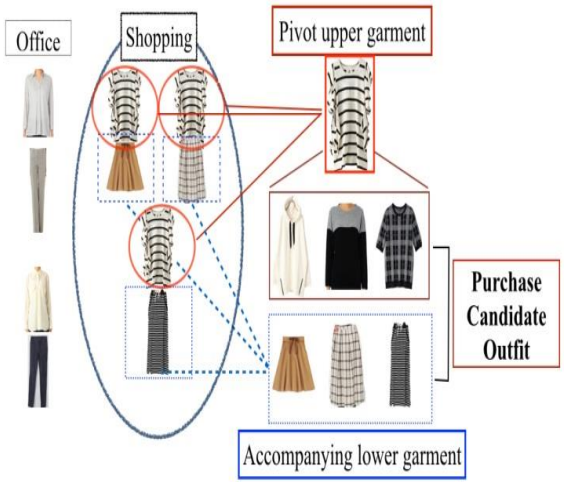

Fig.1. Extract Purchase Candidate Outfit

of users are generally different by TOP.

A user often wares a specific upper garment together with many lower garments, as well as a specific lower one with various upper ones. This is because she tries to increase the variety of her outfits with the combination of garments she has. Therefore, garments a user has can be divided into some groups.

To make the discussion simple, suppose a user combines various lower garments with a specific upper garment. When user garments are divided into groups, each group has the upper garment which plays a pivot role. In the paper, such upper garment is referred to as a pivot upper garment.

The upper garment holding characteristics slightly different from a pivot upper garment can be the garment which satisfies the two conditions explained in section 2.1. The paper refers to a garment which satisfies both of Condition 1 and Condition 2 as purchase candidate upper garment. A purchase candidate upper garment is effective in increasing the variety of outfits utilizing garments users usually wear. The paper refers to lower garments users have coordinated with the pivot upper garment as accompanying lower garments. Since a purchase candidate upper garment is similar to a pivot upper garment has many accompanying lowergarments, the user can coordinate it with many of her lower garments well.

B. Recommendation with multivariate statistics

In this paper, we propose a method to recommend the purchase candidate outfit to assist user to purchase, so that it should enhance user purchase motivation. Fig 2 shows the flow of the proposed method.

First, a user registers pictures of their garments and logs of their outfits consisting of their garments. Frequent appearance of an upper garment together with a lower garment as an outfit in the logs reflects the favorite degree of users for the outfit.

Next, a system applies the correspondence analysis and the k-means clustering to the outfit logs to divide her lower garments into clusters which are similar in the favorite degree from the view point of forming an outfit based on a specific upper garment. At the same time, a system extracts a pivot upper garment from each cluster.

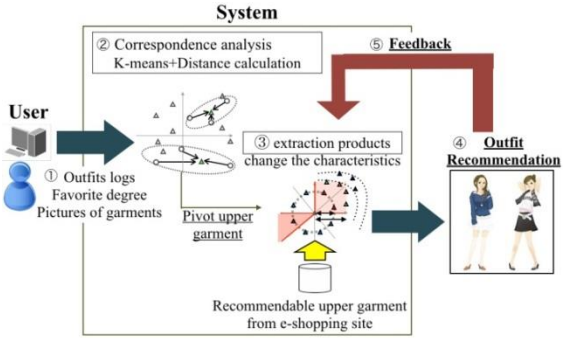

Fig.2. Method Overview

A system extracts a purchase candidate upper garment which holds characteristics slightly different from the pivot upper garment. It coordinates a purchase candidate upper garment with an accompanying lower garment as a purchase candidate outfit. The system recommends the purchase candidate outfits for the user. The system asks her how much she likes the recommended outfits as a feedback indicating her preference for them. The system repeats recommendation, modifying its recommendation way according to the user feedbacks.

C. Extraction of pivot upper garment

The proposed method uses the outfit logs which reflected the favorite degree of users.

To apply the correspondence analysis [9][10] to garments a user registers, the system constructs a matrix, whose row represents each upper garment the user registers, while its column corresponds to each of registered lower garments. The system fills up each cell with the favorite degrees which varies from 1 to 5, where the greater the value, the larger the favorite degree. The favorite degree in each cell stands for the preference of the user for the combination of the upper garment and the lower garment, which corresponds to the row and the column of the cell, respectively. A cell takes a value from 1 to 5, if the user has formed an outfit with them. Otherwise, the system fills up the corresponding cell with 0. In the correspondence analysis, thesystem arranges both rows and columns so that cells of larger values make a line on the main diagonal of a new matrix obtained after the arrangement. It means the new matrix gives the maximum correlation over all cells in it.

To make the explanation concise, let us focus on the favorite degree of lower garments used to form an outfit with a specific upper garment. The new matrix holds lower garments of high favorite degree in near columns, while those of low favorite degree or those appearing in no outfit log in far columns. Let us explain its meaning geometrically. If we plot each cell of the new matrix on a two-dimensional plane, lower garments frequently used to form an outfit with a common upper garment are located on near places. On the other hand, garments seldom or never used to form an outfit are plotted as points of a long distance.

For each of the plotted points corresponding to outfits, the system makes clusters consisting of points locating nearby, applying the k-means clustering to all the point. The result of the clustering shows outfits clustered from the viewpoint of the use frequency in specific situations, which correspond to TPOs explained in section 3.1.

Finally, in each cluster, a system extracts the upper garment which has the minimum sum of distance from all lower garments in the cluster as the pivot upper garment.

Note the method explained above also holds in the case for upper garments used to form an outfit with a specific lower one.

D. Outfits recommendation to reflect user feedback

The method recommends a user a purchase candidate outfit, which consists of a purchase candidate upper garment slightly different from a pivot upper garment and an accompanying lower garment frequently used together with the pivot upper garment.

The method adopts the color of garments as an index to characterize them,becauseusers usually value the colorwhen they purchase garments. The method assumes the color of garments is represented with the two-dimension of the hue and the brightnessbased on the HSV color model [11].The saturation is out of scope of the method, because people would give weight to the hue and the brightness more than the saturation when they judge the color of garments. In the HSV model, the hue rangesfrom 0 to 360, while the brightnessrangesfrom 0 to 100.

The system based on the proposed system analyzes the color of a pivot upper garment and the upper garment an e-shopping site prepares as the recommendation candidates. Here, upper garmentsto be candidate in the recommendationare referred to as recommendable upper garments. Through the analysis, the system recognizes the color of thewidestareas of each garment in an RGB measure. The system regards it as the dominant color of the garment. If the widest area has a specific pattern composed of several color, the system adopts the most dominant color in the pattern.

Next,the garment dominant color represented in the RGB measure is converted into one represented in themeasurebased on the hue and the brightness, using formulas in [11]. In addition, it is expressed as an index vector. The system treats the value pair

$$(h,v) = (\text{hue, brightness}) \quad (1)$$

as the 2 dimensional index vector of the garment. In the conversion, the value of the brightness is multiplied by 3.6 so that the system can deal with brightness values by the same linear measure as hue values.

The index vector of the pivot upper garment is subtracted from the index vector of each recommendable upper garment. The subtraction locates the pivot upper garment on the origin of the coordinate axes.

Let us consider a circle of radius *r*which is calculated with

$$h^2 + v^2 = r^2 \quad (2)$$

Suppose coordinate plane (*h*,*v*) is divided into the area of $s_{1,\ldots,}\ s_8$ based on conditional expression from (3) to (10).

$$s_1 : h^2 + v^2 \ ³ \ r^2, v \ ³ \ 0, v < h \quad (3)$$

$$s_2 : h^2 + v^2 \ ³ \ r^2, h > 0, v \ ³ \ h \quad (4)$$

$$s_3 : h^2 + v^2 \ ³ \ r^2, h £ 0, v > -h \quad (5)$$

$$s_4 : h^2 + v^2 \geq r^2, v > 0, v \leq -h \quad (6)$$

$$s_5 : h^2 + v^2 \geq r^2, v \leq 0, v > h \quad (7)$$

$$s_6 : h^2 + v^2 \geq r^2, h < 0, v \leq h \quad (8)$$

$$s_7 : h^2 + v^2 \geq r^2, h \geq 0, v < -h \quad (9)$$

$$s_8 : h^2 + v^2 \geq r^2, v < 0, v \geq -h \quad (10)$$

In the first recommendation, the system takes a specific initial radius value r_0. The system finds the recommendable upper garment which is away from the origin of the coordinate axes by more than r_0 but closest to the origin in each divided area. The system regards the recommendable upper garments as purchase candidate upper garments. The system combines each of the eight purchase candidate upper garments with an accompanying lower garment to form a default purchase candidate outfit, so that it can recommend each of them to the user.

Each of the eight divided areas indicates a color direction the system propose the user to extend her preference. Default purchase candidate outfits use all of the eight divided areas, because the direction the user likes cannot be presumed at the first time. The user judges whether the extension is acceptable for each direction. The judgment is returned to the system as its feedback.

If the upper garment in area s_i is accepted by the user, radius r is updated with $r=r+\delta$. Calculating in the same way, the system recommends new combinations of purchase candidate upper garments with accompanying lower garments as default purchase candidate outfits. On the other hand, the system provides no recommendation for the areathe user refuses, because it means she does not wish to extend the index vector into the direction.

The system repeats recommendation until the user refuses an acceptance in all areas or is so satisfied with recommendation of outfits that she ends a system.

4. Experiments and Evaluation

A. Experimental Overview

To evaluate the validity of the proposed method, we must investigate the following two verification items.

Purpose 1: Whether the proposed method can recommend the purchase candidate outfit or not

The proposed method enhances user purchase motivation, recommending the purchase candidate outfits. We investigate whether the proposed method can recommend garments which satisfy Conditions 1 and 2 (See Subsection 2.1).

Purpose 2: Whether purchase candidate outfits lead users to purchase or not

This method assumes that the outfits satisfying Conditions 1 and 2 lead users to purchase. To confirm the assumption, we investigate whether users want to purchase them,if they are recommended to the purchase candidate outfits.

There are 2 group of examinees of this experiment;onecontains 32 Japanese women from 19 years old to 30's,and the other consist of 32 Vietnamese women from 21
years old to 30's.

In this experiment, the examinees are recommended the purchase candidate outfits through the following steps. First, examineesregister pictures of their upper garments and lower garments. They register about 10 garments for each. If there are outfit logs indicating every outfit they wear, the system automatically calculates how much they prefer each of the outfits from the frequency of its appearance in the outfit logs. To save the time, we avoid registering outfit logs. Instead, the examinees specify directly the favorite degree for each outfit with a value from 1 to 5. The system treats the data as outfit logs. For combinations of upper garment and lower garmentsthey have never worn, the system sets their favorite degree as 0.

The system based on the proposed method extracts the pivot upper garment using the registered information. The correspondence analysis is applied to calculate the distance between registered garments based on the favorite degree of each examinee. Once the distance is fixed, lower garments are divided into clusters with the k-means clustering. In the experiment, we apply the k-means clustering where k=3. This is because we have judged most women have 3 kinds of situations where they wear different outfits from our pilot study. For all upper garments in each cluster, the system calculatesthesum of the distance from each lower garment in the cluster. It selects the upper garment which has the minimum sum as the pivot upper garment in the cluster.

The system calculates index vectors value of recommendable upper garmentsto extract purchase candidate upper garment based on the procedure of section 3.2.

We have used an e-shopping site, ZOZOTOWN [2], for the search of garments. We have acquired 100 pictures from each of 11 color categories (white, black, gray, brown, green, blue, purple, yellow, pink, red, orange) from the upper garment category of ladies at the e-shopping sites.

The system extracts the recommendable upper garment which is closest to the origin of the coordinate axes in each 8 areas which is specified with the conditional expressions from (1) to (8) explained in section 3.4 as a purchase candidate upper garment. When the system recommended them to the examinees, itcombines each 8 purchase candidate upper garment with an accompanying lower garment as default purchase candidate outfits.The examinees answer whether they accept each default purchase candidate outfit. As it is explained in section 3.4, radius r is updated byr=r+δin the area where a recommended outfit is accepted to repeat recommendation. The system repeatstherecommendation until examinees return no acceptance in any area or they stop the system.

In this experiment, default radius value r_0 and stepδ are fixed to 5.0, because most people feel the color is changedfor the addition of 5.0 to the radian has been turned out to make most people feel the color changed in our pilot study.

After the experiment, examinees answer a questionnaire to evaluate each of the presented outfits. First of all, recommended outfits must be accepted to an examinee.

Let us consider only recommended outfits accepted by a specific examinee. The proposed method is proved to enhance her purchase motivation, if recommended outfits accord her own policy, they increase the variety of her outfits, and they incline her to purchase them. To confirm whether each of accepted purchase candidate outfits satisfies each of Conditions 1 and 2, and whether she wants to purchase it, the following evaluation questions are asked in the questionnaire.

Question 1: Does this outfit match your preference?

Question 2: If you buy this garment, does the variation of the outfit on hand increase?

Question 3: Do you want to purchase this garment?

All of evaluation questions are answered selecting one of "Strongly agree", "Agree", "Neutral", "Disagree", or "Strongly disagree" in the experiment in Vietnam, while they are evaluated by selecting either of "Yes"or"No"inthe experiment in Japan.If the examinee answer is "No", we ask her to state the reason. For an examinee who does not accept a specific outfit recommended by the method, we regard the examinee selects "Strongly disagree" (in the experiment in Vietnam) and "No" (in the experiment in Japan) in all of the three evaluation questions.

B. Evaluation result

We compare the proposed method with an existing method [12], using experimental results.

In the existing method, first, a system classifies garments a user owns into several types based on the similarity of index vectors ofgarments.The index vectors consist of several elements. Let us pick up garments from two similar types. Garments from one type are different from ones from the other type in some elements of the index vectors. The system finds new garments which belong to one type but have values similar to that of garments in the other type. The system recommends them to the user to enhance purchase motivation of the user, expecting they are her unknown garment belonging to her favorite type.

The results in the experiment are depicted in Figure 3, Figure 4, and Figure 5, where the result of the experiment in Japan is expressed with "Proposed (J)", the result of the experiment in Vietnam is expressed with "Proposed (V)", and the result of experiment using the existing method isexpressed with "Existing". In addition the mean values

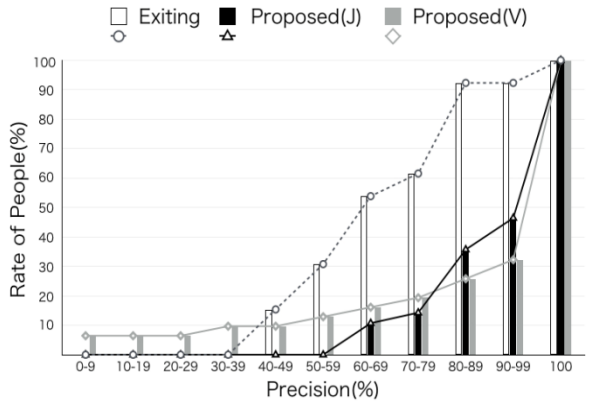

Fig.3. Cumulative Frequency Distribution of the Purchase Candidate Outfits Recommendation

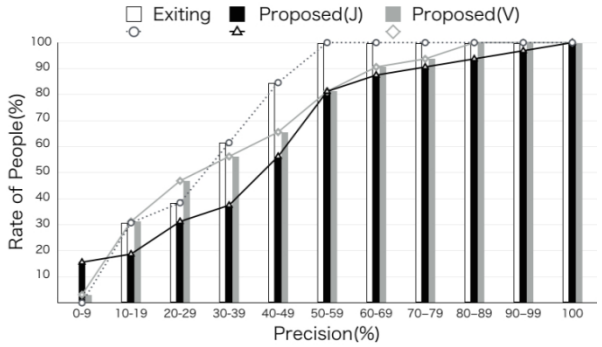

Fig.4. Cumulative Frequency Distribution of Outfits Will Lead To Purchase

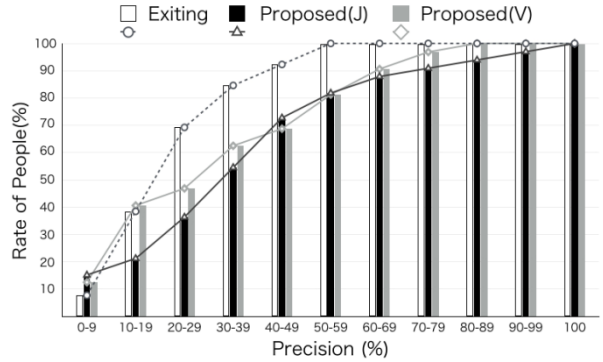

Fig.5. Cumulative Frequency Distribution of the Outfits That the Examinees Want to Purchase

Table 1. The mean values of the precision rate (%)

	(1)(2)	(1)(2)(3)/(1)(2)	(1)(2)(3)
Proposed (J)	42	91	37
Proposed (V)	37	86	33
Existing	32	68	25

of the precision in the experiment are depicted in Table 1. When an examinee answers "Strongly agree" or "Agree" for any of the three validationquestions in the experiment in Vietnam, the answer is regarded as "Yes".

Let us validate Purpose 1, first. For each examinee, the percentage of outfits getting answer "Yes" for both Question 1 and 2 is derived as the precision rate for the examinee. Figure. 3 shows the cumulative frequency distribution of examinees for each value of the precision rate. The vertical axis indicates rate of examinees, while the horizontal axis indicates the precision rate. From Table 1, the mean values of the precision rate for all examinees in Proposed (J) and Proposed (V) are 42% and 37%, respectively. Hence, the proposed method can recommend the purchase candidate outfits with the precision of about 40%.

Next, Purpose 2 is validated. For each examinee, the rate of outfits getting positive answer "Yes" in Question 3 among ones getting positive answers both in Question 1 and 2. This is the precision rate of recommended purchase candidate outfits the examinees want to purchase. Fig.4 shows the cumulative frequency distribution of examinees of specified precision rate. The charts of Proposed (J) and Proposed (V) lean to the right side more than Existing in

Figure.4. It reveals that the proposed method recommends the high conversion rate outfits more than the existing method. From Table 1, the mean values for all examinees in Proposed (J) and in Proposed (V) are 91% and 86%, respectively. These figures imply about 90% ofpurchase candidate outfits lead users to purchase. This result shows the effectiveness of purchase candidate outfits in the recommendation of garments.

Finally, as total evaluation, Figure 5 shows the cumulative frequency distribution of outfits getting positive answers for all three evaluation questions. From Table 1, the mean values in Proposed (J) and in Proposed (V) are 31% and 33%, respectively. This is the precision rate of purchase candidateoutfits users want to buy. The number of displayed garments per page generally varies from 15 to 20 in e-shopping sites which sell garments.According to the precision rate, if this method recommends garments from 15 to 20 for a user, 6 or 7 of them will be purchased. Consequently, the proposed method is useful to enhance user purchase motivation.

5. DISCUSSION

A. Comparison with existing method

The proposed method is superior tothe existing method [12]. The proposed method can recommend not anupper garment alone, but an outfit combininga new upper garment with lower garments a user owns. It makes the precision rate of the proposed method higher than that of the existing method.

From Figure 3, we can know more examinees gives positive answerfor both Question 1 and Question 2 in Proposed (J) and Proposed (V) than in Existing. Proposed (J) improves the mean precision rate over examinees by 10% from the existing method, while Proposed (V) improves it by 18%. This result shows that proposed method can recommend better purchase candidate outfits than the existing method.

Figure 4 shows moreexaminees in Proposed (J) and Proposed (V) give positiveanswersinQuestion 3 for outfits affirmed in both Question 1 and 2 than Existing. The mean precision rate over examineesin Proposed (J) improves by 10% andthatinProposed(V) improves by 18%, compared with that in the exiting method. It indicates garments recommended with the proposed method are more likely to be purchased than those recommended with the existing method.

In Figure 5, moreoutfits in Proposed (J) and Proposed (V) are proved to be affirmed in all three questions than those in Existing. The mean of the precision rate over garments in Proposed (J) is higher than that recommended with the existing method by 12%, and that in Proposed (V) is higher by 8%. This result shows the proposed method can recommend outfits satisfying conditions 1 and 2 enumerated in section 2.1 and leading users to purchase more than an existing method.

These results have revealed the proposed method is more useful to enhance user purchase motivation than the existing method.

B. Accuracy ofrecommendation

Some examinees reject recommended outfits. The reasons of the rejection are “I do not like the silhouette of the garment”, “I do not like the type of collar, or shapes of sleeves”, and“ I do not like the pattern of the garment”.

The proposed method does not consider the preferences of the partial shape and detail characteristics of garments such as silhouette, shapes of sleeves, and patterns. It is necessary to consider the preferences of the partial shape and detail characteristics of garments to extract more accurate individual preferences. The addition of these factors as new indexes can extract more accurate individual preferences.

Other examinees reject recommendation, because “The casual style of the upper garment mismatches with the formal style of the lower garment.”, or “This upper garment does not match this jeans. ”. The proposed method does not consider the consistency in style types of upper and lower garments. Combining the proposed method with an additional method which considersthe consistency of style in outfits such as [4] can resolve the problem.

6. CONCLUSION

This paper has proposed a method to recommend the purchase candidate outfit in order to support users choosing garment on e-shopping sites and enhances their purchase motivation. In this paper, we have proposed a method to recommend the garment which satisfies the following two requirements. The first requirement is to accord to user policies. The second is to promote image change of the user.

First, garments a user already has are divided into some clusters according toher preference. The system based on the proposed method extracts the upper garment that plays a pivot role. The system finds an upper garment having slightly different characteristics from the extracted upper garment,to combine it with lower garmentsshe has worn with the extracted upper garment as outfits. Outfits formedas the combination of new upper garments with lower garments the user has are repeatedly recommended, reflecting her responses.

From an experiment, it is proved that 90% of the recommended outfits matching the above requirements, which motivates the examinees to purchase them. In addition, this method has recommended purchase candidate outfits with 35% of the precision. It means 6 or 7 garments incline a user to purchase them when e-shopping site shows recommended ones from 15 to 20 per page, which is an ordinal case in many sites.

Our future work aims at a comparison of the accuracy with other methods to attempt an evaluation of the usefulness of the proposed method.

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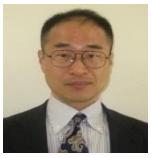

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