An interactive exploratory search system for on-line apparel shopping

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ABSTRACT
Many people (especially women) tend to take relatively longer time for shopping. This paper presents a system for product retrieval inspired by psychology of women's shopping activity, and an implementation of the system for apparel products. Our study supposes products which pre-defined keywords are assigned, and prepares icons representing the combination of the keywords. The system intuitively displays various icons in a display space to demonstrate the diversity of the products. When a user selects an interested icon, the system switches the display to a set of images corresponding to the selected icon, so that the user can visually compare the similar products. The system also features user interfaces to input the preference of users, and reflects the input to the evolutionary computation which adjusts the selection of icons to their preferences. It acts real shopping behavior because we often firstly look over the shops to understand the diversity of products, and then close up the particular groups of the products. This paper introduces an experiment which demonstrates the preferable assistance of the shopping behavior of women who are interested in various products.

Categories and Subject Descriptors
H.3.3 Information search and retrieval, H.5.2 User interface, I.3.8 Computer graphics application, K.4.4 Electric commerce

General Terms
Experimentation, Human Factors.

Keywords
Exploratory search, On-line apparel shopping, Interactive evolutionary computing, Visualization, Icon generation.

1. INTRODUCTION
Shopping is fun for many people. Especially women tend to take a long time for shopping. Economists mention [11] that the following are major reasons for taking long time for shopping:

1) Requirements of consumers are often ambiguous.

2) Curiosity of consumers is not limited to the target products which they want to buy at the moment.

3) Customers often want to continue finding their best products taking a long time.

4) Customers often enjoy shopping processes themselves.

Electric commerce (EC) still increases their market sizes. On-line shopping on the Internet is very convenient because we can purchase various products without visiting to real shops. However, it is often time-consuming or bothering because we need to aggressively query the products while selecting adequate keywords or categories. It is generally easy if consumers want to purchase particular products. Otherwise, we think the on-line shopping processes are not very enjoyable. Especially, many of existing on-line apparel shopping Web sites prepare large number of categories, and therefore users often need to specify adequate combinations of the categories to look for their demanded products. It is often bothering and even stressful.

The concept of "Exploratory Search" [17] has been recently proposed as a framework to support the search process for the users who have ambiguous requirements. We expect this framework should be useful for on-line apparel shopping. This paper presents an interactive exploratory search technique and its implementation for on-line apparel shopping. Based on the comment of economists and our questionnaire results, the presented system aims to satisfy the following three requirements:

[Requirement 1:] It does not always require exact query so that users can enjoy shopping with ambiguous needs.

[Requirement 2:] It firstly shows groups of similar products, and then focuses to individual products in the selected groups, as users often look over the inside of the shops first and then focuses to particular products while the real shopping.

[Requirement 3:] It repeats to display preferable numbers of various product groups reflecting the behavior of users' browsing processes, so that users can be interested in various products.

The system firstly displays various icons representing a certain combination of categories. When a user selects an interested icon, the system displays images of individual products. Users can press "prefer" or "delete" buttons to input their preferences to particular products. They can display the set of preferred products so that they can decide which products to finally purchase. Users can also replace the set of icons to be displayed by pressing "renew" button. The system adequately selects the set of icons to be displayed in the next stage by applying an interactive evolutionary computation algorithm to reflect the behavior of the users. Users can freely look at various products based on their preferences or curious without making explicit queries. The system mainly shows icons based on preferences of users, while showing small number of other icons so that they can be interested in various products.

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2. PRESENTED SYSTEM

This section describes overview and processing flow of the presented technique. The technique firstly displays a set of icons as shown in Figure 1. Here, the icons represent certain combinations of keywords related to the appearance and categories of the products. Users can interchange the set of icons to be displayed by pressing "renew" button. Repetitively displaying the sets of adequate numbers of icons, users can enjoy the search of their preferable products, as they enjoy real shopping by looking at many products over and over.

Figure 1. Snapshot of our technique featuring icon display and graphical user interface.

Here, we suppose the combination of the above mentioned various keywords are also assigned to the all products. Our implementation divides all products into a certain number of groups according to the combinations of keywords, and associates icons to the product groups one-by-one.

When a user clicks one of the icons, the technique switches to display images of individual products in the particular group corresponding to the clicked icons, as shown in Figure 2. Users can focus to each of the images, and press "prefer" or "delete" button for the particular products.

The technique supports two display modes: "icon display mode" for overview of the variety of product groups shown in Figure 1, and "product display mode" focusing on particular groups shown in Figure 2. We think this policy is analogous to real shopping: we often look over the interior of shops to feel diversity of the products, and then focus on particular groups of products to compare the similarity.

2.1 Icon creation

We suppose owners of this system prepare a set of icon images representing the combinations of predefined keywords. Figure 3 shows an example of icon creation process, which represents the combination of keywords, "T-shirt", "red", and "dot". This design policy brings unified impression though the application, and intuitive understanding of product groups corresponding to the combinations of the keywords. We suppose that keywords are defined mainly based on shapes, colors, and patterns of the products, because many customers of the apparel products mainly select the products based on their visual design.

Figure 2. Display of products corresponding to the selected icon.

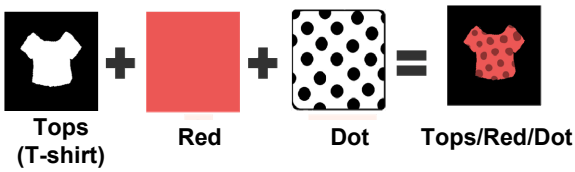

Figure 3. Example of icon creation.

2.2 Icon layout

This technique displays adequate number of icons in a display space as shown in Figure 1, where the icons are selected based on an evolutionary computation algorithm described later. We expect users can be interested in wide range of products by looking at the variety of icons, On the other hand, we need to keep the number of displayed icons not too much, because users may be confused or dithered if too many icons are displayed at the same time.

Our implementation represents the numbers of products corresponding to the icons by their sizes. Users can intuitively understand how many products are prepared in each of the product groups corresponding to the icons.

Here, we suppose the following three conditions for the naturally looking icon layout results:

1) Place similarly looking icons closer.

2) Optimize display space utility. (=Yield less gaps.)

3) Yield no overlaps among the icons.

To satisfy the above conditions for the icon layout, our implementation applies a hybrid force-directed and space-filling algorithm [4], originally developed for graph visualization. The former part of the algorithm connects icons which common keywords are assigned by edges, and supposes attractive forces to the edges. It also supposes repulsive forces among icons which are not connected by the edges. As a result of iterative force calculation, similarly looking icons are closely placed in the display space. The latter part of the algorithm applies a rectangle packing technique so that display space utility is optimized while icons do not overlap each other.

2.3 User Interface

Our implementation features the following user interface widgets.

[Selection of the number of icons:] We featured a menu to select the number of icons to be displayed.

[Selection of keywords:] The right side of the window shown in Figures 1 and 2 features a set of checkboxes to select various attributes including gender of the user, type, price, size, and category of the products. The evolutionary computation algorithm described later selects icons matched to the user-selected keywords. If the user selects no keywords, the algorithm selects icons to be displayed from the every icons. Even if the user does not have any specific target products and therefore does not press any checkboxes, he/she can enjoy the shopping because the system shows arbitrary sets of the icons.

[Icon selection and product display:] When a user clicks an icon by pressing the left button of the mouse, the system displays a set of products in the group corresponding to the clicked icon, as shown in Figure 2. The user can return to the icon display by pressing "return" button featured at the top of Figure 2.

["Prefer" and "Delete" buttons:] While displaying a set of icons as shown in Figure 1, users can select particular icons by pointing the cursor and pressing the right button of the mouse. Similarly, users can select particular products while displaying them as shown in Figure 2. Then, the system shows a small dialog window featuring "prefer" and "delete" buttons. When the user presses the "prefer" button, the icons those assigned keywords are similar to the selected products are preferentially displayed later. On the other hand, when the user presses the "delete" button, the icons those assigned keywords are similar to the selected products are not often displayed later.

2.4 Icon selection algorithm

This system selectively displays a set of icons when a user presses "renew" button, as above mentioned. The displayed icons are automatically selected by the following algorithm. If a user has certain preferences to purchase items, the algorithm mainly selects the user-preferred icons while intensively selecting several other icons so that users can be interested in other kinds of items. Otherwise, the algorithm gradually learns preferences of users while displaying variety of icons to prevent users confusing due to too much randomized selection of icons. Our technique applies an interactive evolutionary computation algorithm to select preferable sets of icons. This section calls previously displayed icons "seed icons", and selected icons to be displayed "derived icons". Moreover, this section formalizes the algorithm with the following variables:

- n : Number of keywords.
- m : Number of icons to be displayed simultaneously.
- $\mathbf{d} = \{d_1, ..., d_n\}$: n-dimensional vector consisting of binary values representing the assignment of the keywords for a product. Here, $d_x = 1$ if the x-th keyword is assigned, otherwise $d_x = 0$.
- $\mathbf{e} = \{e_1, ..., e_n\}$: n-dimensional vector consisting of binary values representing the assignment of the keywords for an icon. Here, $e_x = 1$ if the x-th keyword is assigned, otherwise $e_x = 0$.
- $\mathbf{q} = \{q_1, ..., q_n\}$: n-dimensional vector representing the preference of a user for each keyword. This section calls this value "preference vector". Here, $\mathbf{q}_i$ denotes the value of the preference vector $\mathbf{q}$ when a user pressed "renew" button i times.
- **A**: The set of icons currently displayed.
- **S**: The set of preferentially displayed icons.
- **C**: The set of seed icons.

The processing flow for the icon selection is described below. Here, Steps 1 to 6 are executed when a user presses "renew" button.

Step0: Initialize the preference vector $\mathbf{q}_0$ by the following procedure.

- Reset values of $\mathbf{q}_0$ as 0 if it is for the first time for the user to use this system.
- Inherit the previous values if the user has a history of using this system.

Step1: Let the set of seed icons **C** and icons currently displayed **A** empty.

If the user selected particular keywords: The system firstly select m/3 icons which one or more user-selected selected are assigned, and insert the selected icons to **S**. Also, the system add pre-defined values to the particular dimensions corresponding to the user-selected keywords of the preference vector **q.**

Selection of the icons to be registered in **A**:

- If m_s, the number of icons registered in **S** is smaller than m, the system registers all the icons in **S** to **A**. Then, the system randomly selects (m-m_s) icons and registers to **A**, so that the number of icons in **A** gets m.
- If m_s is equal to m or larger than m, the system randomly extracts m icons from **S** and registers to **A**.

Step2: Display the icons registered in **A**. Users can freely click the icons, look at the groups of products corresponding to the clicked icons, and press "preferred" or "deleted" buttons for the displayed products.

Step3: The system applies Rocchio's algorithm [13] which are originally applied for Relevance feedback. It renews the value of the preference vector $\mathbf{q}_i$ by applying the following equation, where i denotes how many times the user pressed "renew" button.

$$\mathbf{q}_i = \mathbf{q}_{i-1} + \sum_{\mathbf{d}^+ \in D_i^+} \mathbf{d}^+ - \sum_{\mathbf{d}^- \in D_i^-} \mathbf{d}^- + \alpha \sum_{\mathbf{e}^+ \in E_i^+} \mathbf{e}^+$$

$D^+{}_i$: Set of products which user pressed "preferred" button after the user pressed "renew" button i times.

$D^-{}_i$: Set of products which user pressed "deleted" button after the user pressed "renew" button i times.

E^+_i : Set of displayed products after the user pressed "renew" button *i* times.

α : Constant value ($\alpha < 1.0$)

The system preferentially selects the icons which similar sets of keywords are assigned as the products the user pressed "preferred" button, by renewing $\mathbf{q}_i$ by the following equation. Conversely, the system does not willingly selects the icons which similar sets of keywords are assigned as the products the user pressed "deleted" button.

Step4: Insert the icons, those assigned keywords are entirely same as the products which user pressed "preferred" button, to the set of seed icons **C**.

Step5: Specify n_s , the number of icons derived from a seed icon registered in **C**. Our current implementation specifies n_s as a constant number proportional to the number of currently displayed icons in **A**.

Step6: Execute the following procedure for each seed icon $c \in C$.

(1) Copy the e_x value of c, and collect the set of keywords those corresponding values e_x for *c* is zero.

(2) Select the *y*-th keyword from the set of keywords collected in (1), and let $e_y = 1$. Here, let the possibility to select the *y*-th keyword as proportional to the corresponding value of the preference vector q_y . Then, let the values e_z zero, if the *z*-th keyword or the *y*-th keyword selected in (1) is exclusively assigned to the icons.

(3) Specify the icon corresponding to e_z values specified in (2). This process specifies an icon which just one of those assigned keywords is different from c. Register the specified icon to the set of derived icons S.

(4) Repeat (2) to (3) n_s times, for each derived icon in **S**.

(5) Repeat (1) to (4) for each seed icon in **C**.

This algorithm preferentially selects icons those assigned keywords are common with the products which user pressed "prefer" button. During the repetition of evolutionary computation processes, this system selects the icons those just one of the assigned keywords are different from currently displayed icons as the next icons. This mechanism is close to the feeling of real shopping, because usually apparel shops arrange similar products closely. We continuously look at similar products which just have different colors or textures in apparel shops. We expect this mechanism brings users the feeling close to the real shopping.

On the other hand, this system often mixes small number of randomly selected icons, if m_s is smaller than m in Step 1. Keywords of the randomly selected icons are not always quite common with the keywords of the products which the user pressed "prefer" button. This mechanism contributes to mainly show users' preferred groups of products, while sometimes show wide variety of other types of products. We expect this mechanism makes users to satisfy their capricious curiosity to the variety of products, without losing their ambiguous preferences or targets.

3. EXPERIMENT

This section introduces our user experiments which demonstrate the effectiveness of the presented system. All participants of the experiments were female university students.

3.1 Effectiveness of user interfaces

We asked the participants to browse the presented system and an existing EC (electric commerce) Web site for 15 minutes respectively. We recorded their accesses, and counted the numbers of the browsed products. Also, we asked them to write down how they felt during the browsing products. Figure 4 shows the numbers of browsed products by ten participants. This result denotes that most of participants browsed larger number of products while using our system rather than using the existing Web site, as we aimed to develop the system so that users can enjoy to look at many products.

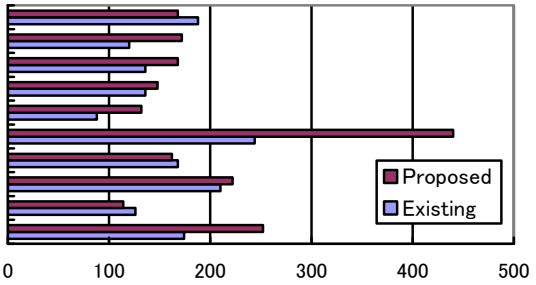

Figure 4 Numbers of browsed products by the participants.

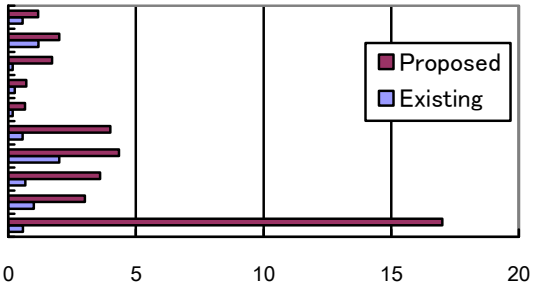

Figure 5 Numbers of keywords assigned to at least one of the products which the participants pressed "prefer" button.

We also counted the numbers of keywords assigned to at least one of the products which the participants pressed "prefer" button. Figure 5 shows the numbers of keywords of the products which the ten participants pressed "prefer" button. This result denotes that the participants are interested in more variety of products while using the presented system rather than using the existing Web site. Though this result demonstrates the effectiveness of the presented system that users were interested in variety of products, we need to discuss that the result might depend on the preferences of icon design of the participants. We heard that several participants clicked particular icons because they felt these were cute. On the other hand, several participants skipped to click particular icons because they did not prefer colors of them. We found that icon design is an important factor for the effectiveness of the presented system, and need to discuss how to customize the icon design based on the preferences of users.

3.2 Effectiveness of icon selection algorithm

Next, we prepared two versions of the presented system. One of them (version A) featured the icon selection algorithm as presented in this paper. The other (version B) just randomly selected icons, while preferentially selecting icons which one or more user-selected keywords were assigned. We evaluated if the icon selection algorithm worked as we expected to mainly show users' preferred products, while sometimes show wide variety of other types of products. In this experiment we focused how participants were interested in products corresponding to the randomly selected icons, not the total number of preferred products, while playing with the presented system. Also, we focused how they found larger number of preferred products if they did not have any particular target products.

Experiment supposing particular targets.

We asked the participants to play with the two versions of the presented system for 15 minutes respectively, after selecting several keywords. Also, we asked them to write down how they felt during the browsing products.

Tables 1 and 2 show the results with the five participants. In the tables, "person" denotes IDs of the participants, "renew" denotes the frequency of pressing "renew" button, "assigned" denotes the number of products which user-selected keywords are assigned and the participant pressed "prefer" button, and "other" denotes the number of products which no user-selected keywords are assigned and the participant pressed "prefer" button. This result denotes all the participants were interested in the products which no user-selected keywords were assigned, and pressed "prefer" button with the products, while playing with the version A. From this result, it is effective to display icons which no user-selected keywords are assigned, because the users may be interested in such unexpected products. On the other hand, the participant E pressed "prefer" button for five products which no user-selected keywords were assigned while using the version B. We need to discuss why the icon selection algorithm was not very effective for the participant E comparing the random icon selection.

We received many positive comments for the version A. Many participants mentioned "I was not tired by this system because it suggested variety of products" or "the system motivated me to browse products we usually did not focus on." On the other hand, a participant mentioned "I was surprised because several icons I did not prefer were displayed". We would like to solve this problem by developing additional indication which suggests users to browse products corresponding to the icons selected by the algorithm which no user-selected keywords are assigned.

Experiment without supposing particular targets.

We also asked the participants to play with the two versions of the presented system without selecting any keywords. Here, it is difficult the presented system precisely selects user-preferred icons in a short experimental test without selecting any keywords, because this system is based on a cold start algorithm. Therefore, we asked them to firstly play with the two versions for 15 minutes. We recorded the preference vector **q**, and then asked them to play with the versions for 15 minutes again. The system loaded the preference vector before the participants played with it.

We counted the numbers of products which the participants pressed "prefer" button. Figure 6 shows the ratio between the numbers of products which ten participants pressed "prefer" button and the numbers of browsed products. This figure denotes that eight of the participants archived the better ratios while using the version A. It demonstrates that users can find larger number of preferable products while applying the icon selection algorithm, when users do not have particular target products and therefore they do not select any keywords.

Table 1 Frequency of renew and number of preferred products while using the version A of the presented system.

person	renew	Assigned	other
A	3	6	3
B	1	12	2
C	2	12	1
D	3	21	3
E	5	3	4

Table 2 Frequency of renew and number of preferred products while using the version B of the presented system.

person	renew	assigned	other
A	1	3	0
B	1	17	0
C	2	10	0
D	4	18	0
E	6	7	5

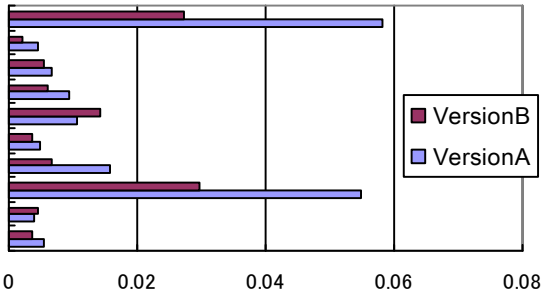

Figure 6 Ration of numbers of products which "prefer" button was pressed by the participants.

4. Related Work

Our original motivation for this research was to satisfy the psychology of women's shopping activities. There have been many publications on women's shopping activities [6,8]. We remarked the conclusions regarding the characteristics of the women's shopping described in [8]. The system presented in this paper does not limit the customers to only women; however, we believe the system is especially preferred by women.

Various issues on on-line commerce business have been discussed as a result of recent evolution, and actually several survey papers on these issues have been published. For example, one of the survey papers [13] mentions that "personalization" and "positive experience" are important issues. On the other hand, we do not think that development of on-line commerce systems based on women's shopping behavior or psychology has not been significantly discussed. Our study presented in this paper addresses these issues.

Recommendation is an important and effective technique for electric commerce and contents viewing. Collaborative filtering [1,7] is one of the most famous and commercially successful recommendation techniques. We agree that collaborative filtering would work well for apparel shopping or some of other kinds of commerce rather than content- or knowledge-based recommendation techniques. However, we do not think such recommendation systems are always satisfactory for apparel shopping. One reason is that lifecycle of apparel products tends to be short, and therefore we do not think cold start systems such as collaborative filtering do not always work well. Another reason is that customers may not want the recommendation systems to recommend the apparel products recommended to the users themselves to other similar customers including their friends. Consequently, we concluded to develop a more visual and interactive system so that users can enjoy a long time for shopping, and the system can gradually learn the preferences of the users while their enjoyable time.

Interactive evolutionary computing is an effective technique to quickly learn the preferences of the users and reuse the acquired knowledge to various applications. Interactive genetic algorithm has been applied to online-shopping [7], collaborative filtering [3] and music recommendation [9]. On the other hand, we preferred to apply the relevance feedback [12] with Rocchio's algorithm, because we expect this algorithm continuously recommends slightly different sets of apparel products over and over. We expect this behavior look similar to that we often look similar products over and over in our real shopping.

Icon synthesis is an important portion in this research, because we expect users enjoy shopping while selecting their interested icons. There have been several techniques for semantics-based icon synthesis [11]. Our icon creation policy is quite similar; however, it is more specific to product keyword representation.

Rectangle placement problem is important for information visualization. Various visualization techniques actually applies rectangle packing, including tree visualization [5] and label placement [2]. The technique we applied for the icon layout [4] has been originally developed for graph visualization; however, it also has preferable properties for our design of icon layout.

5. Conclusion

This paper presented an interactive exploratory search system featuring a relevance feedback algorithm, and its implementation for apparel shopping. Our study is inspired by the research of the psychology and behavior of women's shopping. The presented system firstly displays a variety of icons corresponding to the groups of similar apparel products, so that users can keep wide range of interests. It then displays the images of the products corresponding to the icons selected by the users. This two-step user interface stages diversity and similarity of the products. We think this representation is close to our real shopping: we often look over the shops to understand the diversity of the products, and then close up to particular groups of similar products to narrow down the products we want to buy. Moreover, the system automatically selects the icons to be displayed in the next stage, by applying a relevance feedback algorithm reflecting the behavior of the users. Consequently, the system mainly suggests groups of products based on users' preferences, while it sometimes suggests other kinds of products to satisfy the capricious curiosity of the users. We also expect users can enjoy a long time to select their favorite products while the system quickly learn their preferences to solve the cold start problem of the recommendation systems.

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