Research of Menu Item Grouping Techniques for Dynamic Menus

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Abstract. Menu is an essential widget in human-computer interfaces. Item grouping cues are valuable for target visual search in a menu. In traditional static menus, logically related items are typically grouped by dividing lines. However, the static grouping cues are usually lost in dynamic menus. In this paper, we introduce two novel item grouping cues for dynamic menus, i.e. different background and foreground colors for different item groups. A quantitative experiment was done to compare two adaptive menus with the proposed grouping cues with a typical adaptive split menu. The experimental results reveal that the menu with foreground grouping cues outperformed the other two in speed, and there was no significant difference between the three types of menu designs on accuracy. Most subjects preferred the foreground menu design for its better visual effect.

Introduction

Menus are essential widgets in GUIs. Typically, logically related menu items are positioned together in one group. Menu item grouping cues are valuable for users to reduce visual searching time for a target item. The cues can be usually offered by dividing lines in static menus. However, in dynamic menus, items logically in one group cannot be always guaranteed to keep adjacent. Thus, menu item grouping cues are usually lost in dynamic menus.

In this paper, we introduce two novel menu design techniques. Menu items’ foreground or background colors are employed as grouping cues in each menu design. The menu with foreground or background color cue is called respectively as foreground menu or background menu.

Background and foreground menus are both designed based on adaptive menus [1]. Menu items are kept being relocated according to their selection frequency and recency during a menu is used. The higher of a menu item’s selection frequency and recency are, the higher it is repositioned in the menu [1-3].

To investigate the performance of the two grouping techniques, a comparative experiment was done. In the experiment, we compared two menus that used novel grouping techniques with a traditional adaptive split menu on their performance speeds, accuracy and the participants’ subjective preference. The experimental results show that the foreground menu outperformed the other two.

In the following sections of this paper, we will introduce related work, experimental method, analyze the experimental results, discuss the research and finally present conclusion and future work.

Related Work

There are many studies to enhance performance of the traditional menus, e.g. split menus [1], jumping menu [4], adaptive menus [5], cascade improvements [6], AAMU [7], fisheye menus [8]. These menus are of typically deformed designs of traditional menus.

Jeffrey Mitchell and Ben shneiderman [9] presented a comparative experimental analysis between a static menu (its items were fixed) and a dynamic adaptive menu (the order of its items changed continuously, the most frequently selected menu items appeared in the higher parts of the menu). Leah Findlater and Joanna McGrenere [5] compared the measured and perceived efficiency of three menu conditions: static, adaptable and adaptive. Each of the menus was implemented based on a split menu [1], in which the top four items kept static. Positions of items in an adaptable or adaptive menu
were adjusted by a user or by a computer (according to items’ recently clicked frequencies). Leah Findlater and Joanna McGrenere compared the menus’ performance taking no grouping information into account. Although Kyung Jae Lee and James L. Mohler [10] applied background color design to menu items in the study of visual information coding, but they did none further study for menu item grouping techniques. Andy Cockburn, Carl Gutwin and Saul Greenberg [11] used font size in their ‘morphing’ design, they did not elaborate items’ repositioning in a menu.

Experimental Method

Three kinds of menus were designed based on adaptive split menu [5]. Items were repositioned in each menu according to their used frequency and recency. More frequently and recently selected items were adaptively moved towards higher parts of the menu, less frequently and recently used items towards lower parts. The texts of menu items were selected randomly according to ISO 3166-1 international standard.

Menu Designs

Three kinds of grouping techniques were utilized to offer menu item grouping cues for the three kinds of menus.

**Background grouping technique.** Menu items’ backgrounds in different groups were colored differently. Menu items in one group always had the same background color as their grouping cue no matter whether they were adjacent or not.

**Foreground grouping technique.** Items in different groups had different text colors as their grouping cues. Menu items in one group always had the same foreground color as their grouping cue no matter whether they were adjacent or not.

**Grouping technique in an adaptive split menu.** A horizontal line separated all the items into two groups in an adaptive split menu. Four most frequently and recently used items appeared in the top partition and the remaining items listed in the bottom partition. Therefore, we can think that space was served as menu items’ partial grouping cues.

Menu items were initially ranked in alphabetical order in the three types of menus, for the letter ordering was fast and practical [12]. The experimental initial interface is shown in Fig. 1.

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Figure 1. The experimental initial interface. They are background menu, foreground menu and adaptive split menu from left to right respectively.
Subjects and Apparatus

A total of 12 graduate students (9 males, 3 females, students of computer science), whose ages ranged from 22 to 27, recruited from our university, participated in the experiment. They were familiar with the operation of static menu, but had never contacted with a dynamic menu before.

The experiment was conducted on a PC with AMD A4-5300 APU 3.40GHz processor running MS Windows 8.1. A 19in monitor with a screen resolution of 1920×1080 pixels was used in the experiment. A Microsoft optical mouse was used as the pointing device.

Procedure

The subjects were given a detailed description and explanation about the features and operation of each type of menu. They were conducted to have five minutes’ practice to familiarize the menus and the task.

In the formal experiment, the subjects were required to complete 3 blocks of task trails. During the process, they were asked to complete the experimental tasks with both speed and accuracy as high as possible. There were 16 or 24 items in each type of menu. The items were grouped in 4 or 8 groups in each background or foreground menu and always 2 groups in one adaptive menu. In each block, subjects were required to complete 50 trials under each experimental condition. A Zipfian distribution of selection frequency [11] was used to decide menu items’ used ratio. Menu items were ranked initially in alphabetical order [12]. The subjects performed a total of 12 (subject)×3 (menu type)×3 (block)×2 (menu length)×2 (menu item group)×50 (selection) = 21600 selections. A Latin square was used to counterbalance the order efforts of the three types of grouping techniques. The item numbers and groups changed alternately between subjects.

During the experiment, each target item was displayed with its grouping cue at the top left corner of the experimental interface (see Fig.1). The prompt information of targets alleviated subjects’ memory stress and let them focus their minds on the selection process, and benefited subjects a lot to find the target item in the menu accurately and quickly [10, 13, 14]. When the participants clicked the menu, found and selected the target item, a correct response was rewarded with a happy sound and a “√” mark displayed beside the target’s prompt information (Fig.1), then the experiment advanced to the next trial. If a non-target item was clicked, the experimental program played a “No” sound and displayed a “×” mark. When a wrong selection happened, an experimental error was recorded. Not was the experimental task proceeded to next trial until a trial was done correctly. The subjects were allowed to have a rest between experimental blocks.

After the quantitative experiment, the subjects were investigated for their subjective comments on the three grouping techniques. The questionnaire consisted of the ease of use, hand and eye fatigue and subjective preference (each aspect with seven rating levels, where 1 represented the worst and 7 represented the best).

Results

The experimental dependent variables were trial time and error rate. And the experimental controlling factors included grouping technique (3 levels), block (3 levels), menu length (2 levels) and menu item group (2 levels). We conducted a 3(technique)×3(block)×2(menu length)×2(item group) RM-ANOVA on trial time and error rate.

Selection Time

Mauchly’s test indicated that the assumption of sphericity had been violated for the main effects of grouping technique ($\chi^2 (2) =10.36, p<0.01$) and block ($\chi^2 (2) = 6.9, p<0.05$). Therefore degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity ($\epsilon = 0.61$ for the main effect of grouping technique and 0.67 for the main effect of block). There was a significant effect of the grouping techniques ($F (1.22, 13.37) = 11.58, p<0.005$) on mean selection time. Tests of within-subjects contrasts revealed that mean selection time of foreground menu was significantly less than that of adaptive split menu ($F (1, 11) = 36.32, p<0.0001$). Mean selection time for background,
foreground and adaptive split menus were respectively 1564, 1461 and 1682 milliseconds (Fig. 2). Although the mean time of background menu was 7.5% less than that of adaptive split menu, the difference between them was not significant ($F(1,11) = 3.63, p>0.05$).

Mean selection time in three blocks from 1 to 3 were respectively 1653, 1547 and 1507 milliseconds (Fig. 3). There was also a significant main effect of block on mean selection time ($F(1.34, 14.68) = 20.56, p<0.0001$). This indicated that there was a significant learning effect for the subjects across the three blocks.

Menu length also had a significant main effect on mean task time ($F(1, 11) = 15.21, p<0.005$). Mean pointing time of menus with 16 and 24 items were respectively 1423 and 1715 milliseconds (Fig. 4).

As Fig. 5 shows the mean selection time between menus with different item groups were minute ($F(1, 11) = 0.04, \text{N.S}$). Mean selection time of menus with 4 and 8 groups were respectively 1574 and 1564 milliseconds.
There was no significant interaction effect between grouping technique and menu length \((F (2, 22) = 0.68, \text{N.S})\). Fig.6 shows mean selection time of menus with different grouping techniques and menu lengths (item numbers).

Interaction effect of grouping technique \(\times\) item group was significant \((F (2, 22) = 8.84, p<0.005)\). The subjects spent the minimum mean selection time, 1437 milliseconds, on the experimental tasks of foreground menu with 4 item groups, maximum time on that of adaptive split menu with 8 item groups, 1695 milliseconds (Fig.7).

**Error Rate**

Average wrong item selection percentage of background, foreground and adaptive split menu were respectively 1.7%, 2.2% and 1.6% (Fig.8). The difference between them was not significant \((F (2, 22) = 2.71, p = 0.09)\).

Fig. 9 shows that the error rate had a minute increase in block 3. But there was no significant effect of block on task accuracy \((F (2, 22) = 0.83, \text{N.S})\). Average error rates of experimental blocks from 1 to 3 were respectively 1.9%, 1.7%, 2%.

There was no significant main effect of menu length on task accuracy \((F (1, 11) = 0.13, \text{N.S})\). As Fig.10 illustrates that average error rate of menus with 24 items (1.9%) was a little higher than that of menus with 16 items (1.8%).

Main effect of item groups on selection accuracy was not significant \((F (1, 11) = 0.27, \text{N.S})\) either. Fig.11 illustrates mean selection error rates of menu with 4 groups (1.9%) and 8 groups (1.8%).

There was no significant effect of grouping technique \(\times\) menu length interaction \((F (2, 22) = 0.22, \text{N.S}, \text{see Fig. 12})\) or grouping technique \(\times\) item group number \((F (2, 22) = 0.11, \text{N.S}, \text{see Fig.13})\).

**Participants’ Subjective Comments**

7 out of 12 subjects thought the adaptive split menu was the most prone to fatigue and the foreground was the least. Most subjects believed that they tended to be confused by grouping cues when the number of them exceeded 4.
Discussion

There are three steps to select an item from a menu. They are visual search to find a target from items in a menu, moving cursor onto the target and a click on the target to select it. For most of dynamic menus, it reduces time spent in the second step repositioning more frequently items to higher parts [1]. Our study investigated how to reduce time in the first step. The results shows that fully grouping cues do reduce visual searching time. Both of the two menus with grouping cues performed better on task speed than the adaptive split menu.

But there was only the foreground menu significantly outperformed the adaptive split menu. In fact, background color was a more striking cue than foreground color. We got to know from the subjective questionnaire that large chunks of fill colors were prone to eye fatigue. And this lowered subjects’ performance on the background menu. It may be a better way using mild colors or patterns as background cues to alleviate participants’ fatigue and enhance their performance.

We noticed that error rates increased minutely in the last block. The difference of error rates between blocks was not significant. Therefore, the higher error rate in last block might be caused by chance or by a drawback of dynamic menus. Constantly adjusting items according to their used frequency is a good point of dynamic menus and a drawback at the same time. Keeping items used more frequently and recently near the cursor (appears on the top of a menu when the menu is initially unfolded) can reduce travelling time of the cursor in a menu, that’s the good point. However, changing items’ positions neutralizes users’ learning effect, that’s the drawback of dynamic menus. Additional grouping cues can reduce a dynamic menu’s drawback but cannot eradicate it. During the process of the experiment, when a same target appeared again, some subjects tended to move the cursor to its previous position as they predicted. Repositioning menu items might confuse the participants and make them error-prone.

Conclusions and Future Work

In this paper, we proposed two menu item grouping techniques for dynamic menus, i.e. background fill color and foreground fill color cues. A quantitative experiment was done to compare the performance of the menus with the given grouping cues with the baseline menu, adaptive split menu. The experimental results show that the foreground menu performed significantly better than the baseline.

In our further study, we will investigate more possible grouping techniques for dynamic menus.

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References


