Chapter 8
Modeling Human Behavior to Reduce Navigation Time of Menu Items:
Menu Item Prediction Based on Markov Chain

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ABSTRACT

With the increase in the number of menu items and the menu structure complexity, users have to spend more time in locating menu items when using menu-based interfaces. Recently, adaptive menu techniques have been explored to reduce the time and menu item prediction plays a crucial role in the techniques. Unfortunately, there still lacks effective prediction models for menu items. This chapter per the authors explores the potential of three prediction models based on Markov chain in predicting top n menu items with human behavior data while interacting with menus - the users' historical menu item selections. The results show that Weighted Markov Chain using Genetic Algorithm can obtain the highest prediction accuracy and significantly decrease navigation time by 22.6% when N equals 4 as compared to the static counterpart. Two application scenarios of these models on mobile devices and desktop also demonstrated the potentials in daily usage to reduce the time spent to search target menu items.

INTRODUCTION

With the increase in menu items and the menu structure complexity, users have to spend more time and efforts in locating menu items when using WIMP (windows, icons, menus, pointer) interfaces, and this tends to cause the decrease in task performance and extra mental load. How to decrease the visual search

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time of menu items and improve task performance has been an open problem in the HCI (human-computer interaction) field. Although some research efforts have been made to solve the problem, most of them focused on the optimization of static menu structure such as menu item grouping (E. Lee & MacGregor, 1985; Norman, 1991), layout (Cockburn, Gutwin, & Greenberg, 2007) and format (Parkinson, Sisson, & Snowberry, 1985; Shih & Goonetilleke, 1998). These approaches can decrease the navigation time and improve task performance to some extent, but their efficacy is evidently decreasing with the increase of menu structure complexity and the number of menu items.

A few more efforts have also been made to explore adaptive menu technologies in response to the challenge. Adaptive menu technologies usually rely on three approaches: spatial, graphical or ephemeral. Spatial approaches (L. Findlater & McGrenere, 2008; Mitchell & Shneiderman, 1989) re-organize menu items to reduce navigation time and, to a lesser degree, to aid visual search. For example, an adaptive split menu moves or copies the most frequently and/or recently used items to the top of the menu for easier access (K. Z. Gajos, Czerwinski, Tan, & Weld, 2006). The main drawback of this approach is that spatial consistency cannot be maintained (Cockburn et al., 2007). For graphical approaches, they reduce navigation time through changing the background of predicted items (K. Gajos et al., 2005; K. Z. Gajos et al., 2006; Tsandilas & Schraefel, 2005).

As an alternative to spatial and graphical adaptation, Leah Findlater, Moffatt, McGrenere, and Dawson (2009) proposed the use of a temporal dimension and introduced *ephemeral adaptation* as a new adaptive menu technique to reduce navigation time. Ephemeral adaptive approaches use a combination of abrupt and gradual onset to provide initial adaptive support, which then gradually fades away; The goal is to draw the user's attention to a subset of adaptively predicted items, thus, reducing visual search time. To demonstrate the benefit of ephemeral adaptation, they further compared the effects of two predefined conditions of prediction accuracy (50% VS. 79%). The results show that when the accuracy with which the adaptive algorithm predicts the users' needs is relatively high (79%), ephemeral adaptation significantly offers better performance and user satisfaction benefits over traditional static menus, and a performance benefit over a graphical adaptation technique, whereas it does not, when adaptive accuracy is low (50%). It suggests that obtaining high prediction accuracy of menu items is crucial to the success of adaptive menus. However, there still lacks an effective prediction method of menu items based on historical menu click data.

Conventional prediction models are merely based on frequencies, *Most Frequently Used* (MFU) or time, such as *Most Recently Used* (MRU), or both including *Split Recency and Frequency*(SR&F) (Leah Findlater & McGrenere, 2004) and *Combined Recency and Frequency*(CRF) (D. Lee et al., 1999). However, the accuracy of these methods are usually low.

More sophisticated models utilized context information (e.g., at a bus station or in an office). Kamisaka, Muramatsu, Yokoyama, and Iwamoto (2009) utilized a wrapper algorithm to select features from time and position attributes for a Naive Bayes classifier (NB) to recommend applications for mobile devices. This NB model was better than conventional algorithms, zero-attribute rule (ZeroR), which is a simple and light-weight MFU-based method. However, they didn't find location attributes useful to the item order. Kurihara, Moriyama, and Numao (2013) proposed another context-aware approach, event frequency - inverse context frequency (EF-ICF), based on term frequency - inverse document frequency (TF-IDF) to create a prediction model, where the contexts (i.e., location, time and both) correspond to document and application events to terms. They then utilized a split menu to combine the frequency based ranking list and the context based ranking list. Their results showed an improvement on the NB

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