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Adaptive visualization for exploratory information retrieval

Jae-wook Ahn [a,*], Peter Brusilovsky [b]

[a] Human–Computer Interaction Lab, University of Maryland, 2117 Hornbake Bldg, South Wing, College Park, MD 20742, United States
[b] School of Information Sciences, University of Pittsburgh, 135 North Bellefield Ave., Pittsburgh, PA 15260, United States

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ABSTRACT

As the volume and breadth of online information is rapidly increasing, ad hoc search systems become less and less efficient to answer information needs of modern users. To support the growing complexity of search tasks, researchers in the field of information developed and explored a range of approaches that extend the traditional ad hoc retrieval paradigm. Among these approaches, personalized search systems and exploratory search systems attracted many followers. Personalized search explored the power of artificial intelligence techniques to provide tailored search results according to different user interests, contexts, and tasks. In contrast, exploratory search capitalized on the power of human intelligence by providing users with more powerful interfaces to support the search process. As these approaches are not contradictory, we believe that they can re-enforce each other. We argue that the effectiveness of personalized search systems may be increased by allowing users to interact with the system and learn/investigate the problem in order to reach the final goal. We also suggest that an interactive visualization approach could offer a good ground to combine the strong sides of personalized and exploratory search approaches. This paper proposes a specific way to integrate interactive visualization and personalized search and introduces an adaptive visualization based search system Adaptive VIBE that implements it. We tested the effectiveness of Adaptive VIBE and investigated its strengths and weaknesses by conducting a full-scale user study. The results show that Adaptive VIBE can improve the precision and the productivity of the personalized search system while helping users to discover more diverse sets of information.

1. Introduction

Today's information environment is getting more and more complicated each day. How to locate relevant information in this complexity and to distill valuable information is one of the biggest challenges. In the past, the most successful information access tools were directory services and web-based search engines. Despite their success, they have limitations to deal with different user search conditions and the problem of users' lack of the knowledge or contextual awareness to formulate queries or navigate complex information spaces (Bates, 1989; White, Kules, & Bederson, 2005, 2006).

One of the promising ideas that can address this problem is *personalized search* (Micarelli, Gasparetti, Sciarrone, & Gauch, 2007; Pitkow et al., 2002). Unlike traditional search, it tries to avoid the one-size-fits-all strategy and understand user differences – different user interests or different contexts – and then provides more customized results to meet specific user interests under different contexts. In order to accomplish this goal, personalized search systems usually adopt user models, which maintain the information about the users, their interests, tasks, or search contexts (Gauch, Speretta, Chandramouli, & Micarelli, 2007). Utilizing user models, dynamic contexts can be integrated into personalized retrieval models.

* Corresponding author.
E-mail address: jaewook.ahn@gmail.com (Jae-wook Ahn).

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Over the last 20 years, the concept of personalized search has been explored in a number of projects. Multiple studies have demonstrated the benefits of this technology. However, the problem is that the majority of them focused on the classic low-interactive search model: a search engine receives a query from users and then returns the most relevant document surrogates in a ranked list. In this case, the user interaction with the system is limited to issuing a query and examining the ranked results. In the early days of personalized search, less interactivity was the standard for all kinds information retrieval systems and personalized systems. Currently a low-interactive approach falls behind the state-of-the-art research in both fields. For more than a decade, a volume of research in the field of information retrieval was devoted to an alternative approach to handle the growing complexity of search tasks known as *exploratory search systems* (Marchionini, 2006). Exploratory search systems focused on supporting more complicated search tasks in case where traditional search systems were less than adequate. Exploratory search stresses the importance of highly interactive user interfaces, so that users can learn and understand their problems more thoroughly while actively interacting with the system. Going beyond the simple look-up search activities can produce better results.

As these approaches explored by personalized and exploratory search systems are not contradictory, we believe that they can re-enforce each other. We argue that the effectiveness of personalized search systems may be increased by allowing users to interact with the system and learn/investigate the problem in order to reach the final goal. The value of combining positive sides of personalization and interactivity has already been demonstrated in some other types of personalized systems. While classic personalized systems focused on sophisticated approaches to modeling user interests, goals, and other features by observing a relatively low flow of user actions, the modern trend is to engage users of adaptive systems in a richer interaction and to use the increased diversity and volume of user activities for more reliable user modeling. One of the earliest examples of this trend was the MetadDoc system (Boyle & Encarnacion, 1994). MetaDoc replaced classic one-shot page content adaptation with so-called adaptive stretchtext that allowed users to expand or collapse content fragments. This increased the volume of information that the system received from the user and allowed MetaDoc to build more reliable user models and offer better personalization.

The challenge that we address in this paper is how to develop personalized interactive search systems that can incorporate recent developments from both contributing fields. On one hand, we want to develop systems that can offer useful personalization for modern interactive search approaches such as used in many exploratory search systems. On the other hand, we want to focus on creating user interactions that can improve the opportunities for more reliable user modeling.

In our previous work, we have investigated several ideas for this personalized interactive search. Our systems allowed users to have more control over the personalization process and we explored options to help users view and manipulate the user models (Ahn, Brusilovsky, Grady, He, & Syn, 2007) as well as to control the impact of the user models on search results (Ahn, Brusilovsky, He, Grady, & Li, 2008). However, the interactivity of the approaches that we explored was limited, because they were still based on a traditional static ranked list approach that offered little support for exploratory search tasks. In this paper, we extend the previous attempts by exploring personalization approaches for a more interactive search scenario. A relevance-based visualization framework called VIBE (Visual Information Browsing Environment) (Olsen, Korfhage, Sochats, Spring, & Williams, 1993) was chosen as an example of a highly-interactive search approach.

VIBE makes use of reference points called POIs (Points of Interest) and can position documents according to their similarity ratios to the POIs. To introduce a search-focused personalization to VIBE, we defined user queries and user model keywords as POIs and provided means to organize them spatially in the visualization. Users can explore this personalized visual space easily and search for relevant information within it. The resulting personalized visual search system was called Adaptive VIBE. By combining personalization and visualization-based exploratory search, we expect Adaptive VIBE could solve the problems in traditional non-personalized and static information retrieval and the complexity issue of personalized search. We conducted a user study in order to prove the value of Adaptive VIBE and to investigate its properties to facilitate future improvements. This paper introduces the details about the Adaptive VIBE system features and discusses the user study results. The next section explores related studies regarding visual exploration for information retrieval and adaptive visualization. Section 3 introduces the Adaptive VIBE system and the implementation details. Sections 4 and 5 explain the design and the result of the user study. Section 6 summarizes and discusses the implications of the results. The last section concludes this paper and presents future plans.

2. Related studies

We propose a technology that combines the knowledge from several fields, particularly these three broad categories: (1) information retrieval supported by exploratory visualization, (2) personalized search, and (3) adaptive visualization.

2.1. Visual exploration for information retrieval

Exploratory search is a non-static information retrieval approach that focuses on users' ability to control, learn, and discover information during the interaction with the system. It emphasizes on iterative user interfaces and understands the information retrieval process as a learning or investigatory process rather than a simple lookup search (Marchionini, 2006). The target space and the nature of the problem of exploratory search is uncertain (White et al., 2005), so every