What You See Is What You Search:
Adaptive Visual Search Framework for the Web

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ABSTRACT

Information retrieval is one of the most popular information access methods for overcoming the information overload problem of the Web. However, its interaction model is still utilizing the old text-based ranked lists and static interaction algorithm. In this paper, we introduce our adaptive visualization approach for searching the Web, which we call Adaptive VIBE. It is an extended version of a reference point-based spatial visualization algorithm, and is designed to serve as a user interaction module for a personalized search system. Personalized search can incorporate dynamic user interests and different contexts, improving search results. When it is combined with adaptive visualization, it can encourage users to become involved in the search process more actively by exploring the information space and learning new facts for effective searching. In this paper, we introduce the rationale and functions of our adaptive visualization approach and discuss the approaches' potential to create a better search environment for the Web.

Categories and Subject Descriptors

H.3.3 [**Information Search and Retrieval**]: Information filtering; Relevance feedback; H.5.2 [**User Interfaces**]: Graphical user interfaces (GUI)

General Terms

Algorithms, Design, Experimentation, Human Factors

1. INTRODUCTION

The Web is suffering from information overload. It is a universal source for production as well as consumption of information. In particular, people are producing more and more new information due to the development of recent Web technologies such as Weblogs, Twitter, wikis, and other social networking services. One of the most popular and common solutions to this overload problem is searching. It aims to enable users to locate the information that they need quickly and precisely. However, it is still far from perfection and many researchers are still trying to improve existing search algorithms. Personalized search [3] is an approach to provide users with tailored search results, beyond the *one-size-fits-all* strategy. Exploratory search [2] is an idea that stresses the interaction between the user and the system, so that users can learn about the problem space while they are exploring it with the help of the system. Eventually, they will be able to locate the relevant information. Adaptive visual search is mixture of personalized and exploratory search, which tries to achieve the strengths of those
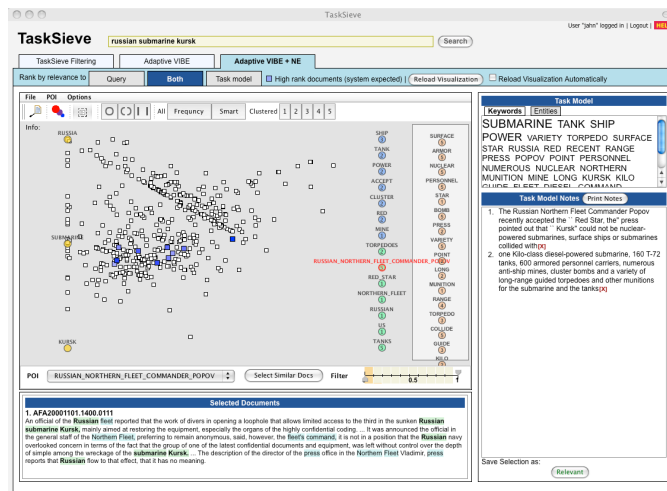
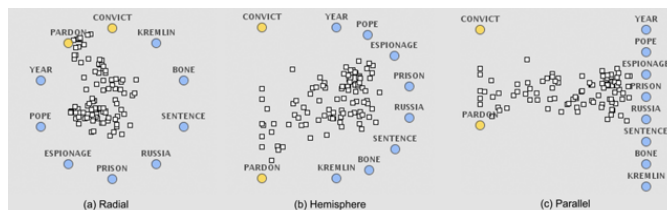**Figure 1: Prototype implementation of the proposed adaptive visual search environment**

Figure 2: Adaptive VIBE layouts – adaptive (b) and (c) layouts separate the query (yellow/left) and the user model (blue/right)

two extremes. It incorporates interactive and visual interfaces into personalized search and implements adaptive visualization for the personalized search framework. In order to realize this idea in the Web environment, we extended a well-known visualization framework called VIBE (Visual Information Browsing Environment) [4]. It is a reference point-based spatial visualization algorithm and has been deemed adequate to display search results – visualizing retrieved documents and queries. We re-implemented the algorithm so that it can be more appropriate for the new Web environment. We extended it even more to realize an adaptive visualization and incorporated it into a personalized search system. Therefore, we were able to construct an adaptive visual search framework. We have named it "Adaptive VIBE."

2. ADAPTIVE VIBE FRAMEWORK

VIBE is a reference point (Point of Interest, or POI)-based visualization. That is, it displays the POIs that represent specific concepts or keywords, and distributes documents according to their similarity ratios to the POIs. Therefore, documents are placed closer
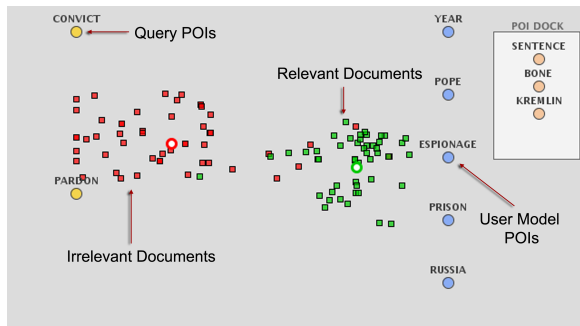
Figure 3: Adaptive VIBE experiment – green and red squares mean relevant/irrelevant documents.

to more similar POIs and users can discover documents by their proximity to a particular set of POIs. We added adaptivity to this foundational algorithm by changing the way the POIs are displayed; it is implemented in Figure 1. VIBE-based IR visualization approaches usually use a *radial* layout for their initial placement of POIs (Figure 2a). Like a round table, all POIs are equal in this scenario. However, our application requires that we distinguish between the two groups of documents retrieved by user models and by user queries. By this discrimination, users would be able to know which documents are more affected by the user queries and which documents are more about the user models. Here, the user model represents user interests or contexts and is comprised of a set of keywords collected during the system-user interaction. We could achieve this discrimination by separating the groups of POIs spatially on the screen. Two new layouts (b and c in Figure 2) attempt to locate two groups of POIs – query and user model POIs – in horizontally separate places and then break up the spaces between the two groups. Through this POI group separation, the documents under the effect of each group are separated spatially again and the users can easily investigate each cluster of documents to discover relevant information. Figure 3 is an example of search result visualization that could be benefit from this adaptivity. Thanks to the separation of the query and the user model, the documents formed two clusters: each of them contains irrelevant and relevant documents respectively, and the relevant one is closer to the user model. By following the document cluster closer to the user model, the user can locate relevant information quickly. We have conducted a preliminary experiment using an existing dataset and the details are shown in [1].

3. IMPROVING VISUAL USER MODELS

3.1 Concept-Level User Modeling

In our first implementation, the elements of the user models were always keywords (or terms). Even though the keyword-based user models were working relatively well, we expected that concept-based user models would prove more helpful than the simple keywords. Therefore, we extracted named-entities and used them as user model elements by showing them as POIs on the visualization. As in Figure 1, users can examine and exploit more semantic-rich named-entities (e.g. *NORTHERN_FLEET* painted in green) for exploring the documents.

3.2 Smart POI Selection

The real estate on the screen is limited and the number of POIs that can be efficiently displayed at the same time is not very big. According to our experience, the maximum would be between 15 and 20; more POIs will make users frustrated and confused. Therefore, it is an important issue to select the POIs to be displayed in

Figure 4: Filtering documents from a POI

the first place. We originally selected the POIs that have higher *TF-IDF* scores. However, we felt a need to devise a more visualization-oriented approach. That is, we sought a new set of POIs to make the visualization better, and in this case, make the distribution of documents less cluttered. We solved this problem by calculating the average distance between the screen center and every document on the screen when a specific POI was *removed*. When a specific POI was removed from the entire set of POIs, and the average distance is reduced, that amount of reduction was considered as the contribution of the POI that made the visualization more spread across the screen. This $spread\_score$ was calculated for each POI; the top N POIs with higher $spread\_scores$ were selected.

4. SPATIAL USER INTERACTION

Adaptive VIBE was equipped with new functions that can help users to better explore the problem space interactively. These features change the methods of user interaction to go beyond the static text-based ranked lists of conventional Web search engines.

Spatial filtering of retrieved documents – Users can select (or filter) documents spatially in the visualization using a marquee tool. Detailed information such as titles, surrogates, and the links to the fulltext of the selected documents are displayed. Because spatial distribution of the documents is tightly connected to the aboutness of the documents (more about UM, query, or a specific POI), this selection tool can let users learn more promptly the contexts of the retrieved documents. ***Linking POI and document filtering by a double slider*** – Users can directly point to a POI and filter documents related to the POI (and select/see the detailed information of the documents). They can specify the lower and upper similarity thresholds of the documents to the POI using a double slider (Figure 4). This function plays a similar role in the marquee selection method, but is expected to help users to select documents more precisely in a reverse direction, from a POI to documents. ***POI dock*** – Sometimes, too many POIs present at the same time on the screen can make users feel lost and frustrated. However, we cannot just limit the amount of information that users can access. Therefore, we added a special area where some POIs are temporarily moved out so that their effects on the visualization are disabled. We call it a POI dock, which is shown in Figure 1 next to the user model POIs. Users can drag POIs to/from this area and interactively examine the effect of each POI they are interested in.

5. CONCLUSIONS

This paper introduces our efforts to implement an adaptive visual search framework for the Web. We have extended a well-known spatial visualization algorithm to adaptive visualization and have investigated its effectiveness. The core features of this idea include user model visualization for personalized search, concept-level user modeling, smart POI selection, and interactive spatial exploration. We are planning to conduct a full-scale user study in the near future and to learn the strengths and the shortcomings of this approach.

6. REFERENCES

[1] J.-w. Ahn and P. Brusilovsky. Adaptive visualization of search results: Bringing user models to visual analytics. *Information Visualization*, 8(3):167–179, 2009.

[2] G. Marchionini. Exploratory search: from finding to understanding. *Commun. ACM*, 49(4):41–46, April 2006.

[3] A. Micarelli, F. Gasparetti, F. Sciarrone, and S. Gauch. Personalized search on the world wide web. pages 195–230. 2007.

[4] K. A. Olsen, R. R. Korfhage, K. M. Sochats, M. B. Spring, and J. G. Williams. Visualization of a document collection: the vibe system. *Inf. Process. Manage.*, 29(1):69–81, 1993.