Use of Visualization to Assist the User with Term Selection for Query Expansion

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Abstract

Information is the most abundant resource in the modern world. The amount of information available to the general public has grown tremendously. Unfortunately methods of searching through this abundance of information have not kept pace. Visualization systems have been developed to display large amounts of information in an intuitive and space-efficient manner. In this paper we describe an intuitive user interface for identifying closely related terms. Many existing visualization systems are too complicated and require an expert user. We have focused our design specifically on casual searchers, i.e. those without formal training in library science or information retrieval.

Our visualization paradigm is a dartboard. Each ring of the board is a different color and represents a different degree of similarity with the central word. The term-term visualization system that we developed has been integrated with a simple vector space search and retrieval application.

1 Introduction

Existing search tools frequently frustrate users, especially those untrained in library science or information retrieval. This is easily seen by the casual searcher who wants to look up different breeds of poodles on the Internet. For example, a keyword search of "poodle breed" will most likely return millions of hits, many of which have nothing to with either poodles or breeds of dogs.

This project focuses on the use of visualization to assist user driven query refinement. Query refinement generally occurs from reading page after page of somewhat useful information until the user collects enough knowledge to string together important keywords that will finally retrieve the appropriate result [2]. We have created a display which will allow users to refine their search in a more efficient manner and eliminate the time consuming reading of off-target information.

We begin this paper with a discussion of the related work in Section 2. In Section 3 we describe our search and retrieval system, including the visualization component. We have not yet had a chance to complete a formal usability study of our system, but we present anecdotal evidence for its usefulness in Section 4. We also desecribe our evaluation methodology in Section 4. We expect to have the results of our usability study available before the final version of this paper is due in November. We summarize in Section 5.

2 Related Work

In this section we discuss previous work in the field of visualization for information retrieval, particularly visualization of term-term relationships. Generally visualization systems can be classified as either two-dimensional or three-dimensional. Other researchers have performed formal studies of the pros and cons of 2-D vs. 3-D visualization systems [10, 9], and we will not attempt to duplicate that data here. In what follows we provide some of our own observations about the shortcomings of current systems. We also note that many visualization systems for document clustering have been developed (we refer the reader to `http://`

www.iturls.com/English/TechHotspot/TH_DocCluster.asp for a list of references). Our discussion in this section will focus on term-term relationships instead of document clusters.

Chen, et al. describe a two-dimensional text relationship mapping system in [3]. The authors note that the system was particularly useful as a tool for query refinement. The terms identified using the visualization system were more useful in narrowing a query than were terms that searchers identified on their own. Unfortunately, feedback also indicated that the user interface needed to be improved. The authors conclude that the system either needs a set of help screens (or another mechanism for user instruction), or a more intuitive user interface. We found the interface to be very cluttered, and the relationship between adjoining regions was not intuitively obvious.

Another 2-D system is described in [8]. The 2-D tree structure was created for analyzing term-term relationships. 2-D tree structures are very popular [8, 5, 7], but we feel these displays suffer from cluttering problems and lack visual aids to signify how terms are related within the display, especially as the number of terms on the display increases [5, 7].

3-D systems appear to primarily be applied to document clustering problems. [4] describes one such system that provides a great deal of insight into the pros and cons of 3-D displays. The display in [4] is very powerful, but the objects in the background were difficult to see. We noticed that the rotating display resulted in overlapping near the edges of the display and causes distortion of objects. Furthermore, there was a lot of empty space in the display, resulting in a system that did not take full advantage of the space provided.

In the next section, we describe our system for visualization of term relationships. When developing our system, the discussion of design principles in the field of human-computer interaction found in [1] proved very useful.

3 Overview of the Interface

Many of the existing visualization systems we reviewed were very complicated. We feared that only an expert user, or the system designer, would be able to effectively use the system. Our project tries to avoid such complexity while offering useful feedback. We assume that the user will remain in control of the retrieval task during the entire session. Our interface merely suggests terms that may be added to the query at the user's discretion.

Our interface employs a dartboard, or bull's eye, paradigm. The user initiates a query, as shown in Figure 1, and then can choose to display the dartboard by clicking on the appropriate command button. The main query term appears in the center of the dartboard. To date, we assume that the first query term is the main term. All terms that are similar to the main term are then retrieved and displayed in rings around the main term as shown in Figure 2. Colors are used to easily distinguish the different dartboard rings.

Currently the term-term similarity is precomputed and provided to the visualization system. The term-term similarity provided by the Latent Semantic Indexing (LSI) algorithm [6] is currently used, although any function that computes term-term similarity can be seamlessly integrated. The 20 terms most closely related to the main term fall into the first ring of the dartboard. The next 30 related terms are placed in the outer ring. The placement of the terms within each ring is random. In choosing this method, we note that current methods of computing term-term similarity are imperfect, and therefore a scheme that attempts to place terms strictly using the similarity measure are unlikely to provide added benefit. Furthermore, even if a perfect similarity measure were available, users are unlikely to distinquish between close similarity values (e.g. .98 vs. .91). Trying to display or represent the actual measure would only clutter the display.

To satisfy our goal of a user driven interface, we provide features which allow the user to further manage the query. For example, the user can drag terms within the display to organize them into similar groups.

Figure 1: User Interface for Query Entry

Figure 2: Dartboard Display for First Query Term

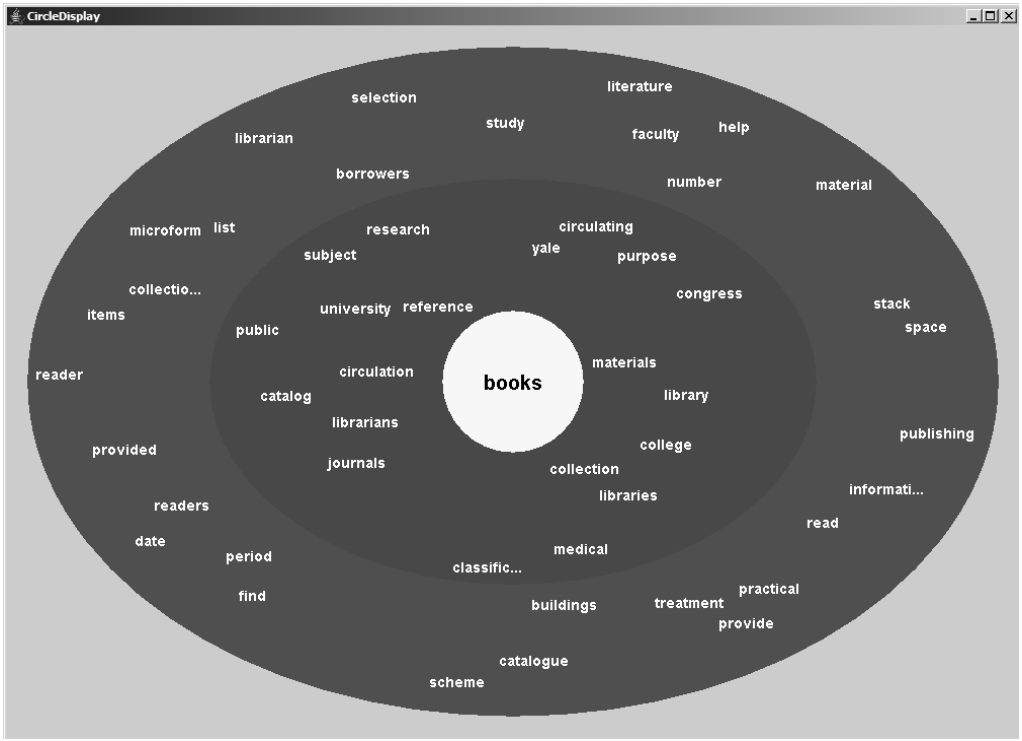
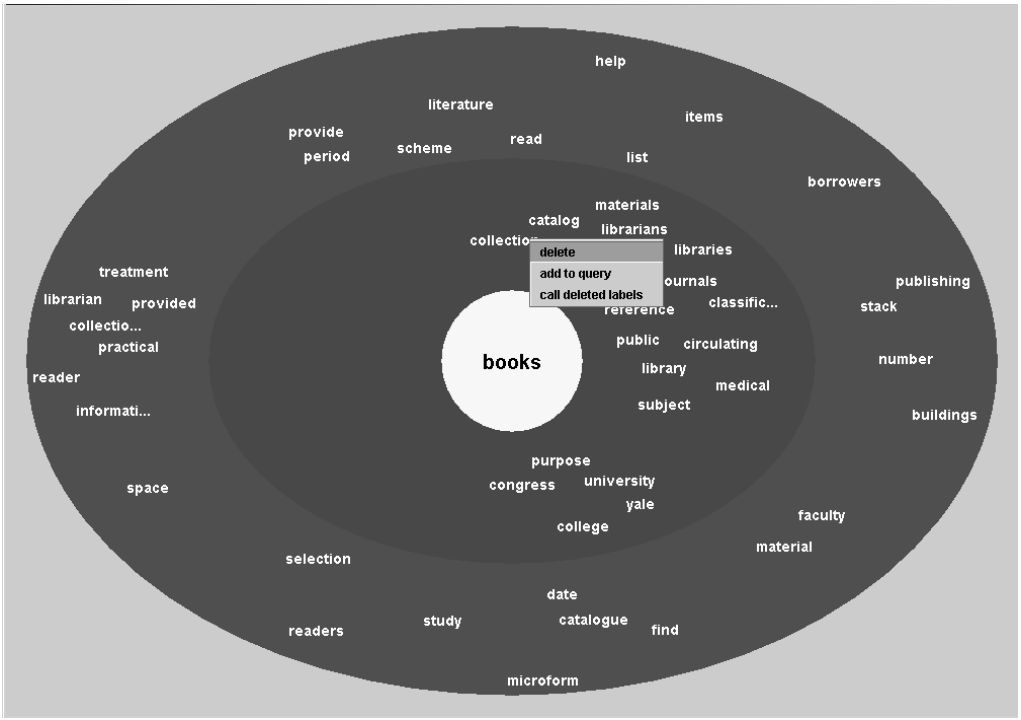


Figure 3: Pop-up Menu for User Control Functions



Movement across ring boundaries is allowed. The user may also delete terms from the display by right-clicking on a term and selecting the corresponding option from a pop-up menu. Most importantly, the user can add terms to the original query using the right-click pop-up menu (see Figure 3).

4 Evaluation

In this section we first describe the initial response from potential users to our visualization system. We next describe the methodology we will employ to complete a formal usability study of our interface. We plan to complete the usability study in October 2004, and we expected the results to be available for the final version of this article.

4.1 Initial Reactions

We had the opportunity to demonstrate our system at an undergraduate symposium at a small liberal arts college. The symposium was the culmination of the summer projects undertaken by approximately 70 undergraduates in a wide variety of disciplines encompassing the humanities, social sciences and sciences. Only three computer science students participated in the symposium. The audience consisted of undergraduate presenters, their mentors, their parents, high school students, and other interested parties from the university community. The audience for our demonstration was varied and non-technical.

The first notable reaction to the demonstration was that a large portion of the audience was familar with searching, and the problems it presents. The second response was the development, by the audience, of a list of suggestions for improving the interface. One gentlemen suggested adding a outline drawing tool, so

Topic Number	Topic Name	Description
303i	Hubble Telescope Achievements	Identify positive accomplishments of the Hubble telescope since it was launched in 1991.
307i	New Hydroelectric Projects	Identify hydroelectric projects proposed or under construction by country and location. Detailed description of nature, extent, purpose, problems, and consequences is desirable.
322i	International Art Crime	Isolate instances of fraud or embezzlement in the international art trade.
326i	Ferry Sinkings	Any report of a ferry sinking where 100 or more people lost their lives.
339i	Alzheimer's Drug Treatment	What drugs are being used in the treatment of Alzheimer's Disease and how successful are they?
347i	Wildlife Extinction	The spotted owl episode in America highlighted U.S. efforts to prevent the extinction of wildlife species. What is not well known is the effort of other countries to prevent the demise of species native to their countries. What other countries have begun efforts to prevent such declines?

Table 1: Topics from TREC-6 Interactive Track

that once the terms in the dartboard were rearranged to the user's satisfaction, a group could be selected and added to the query with one click. Another person suggested allowing multiple terms in the center ring. The effect of this change generated discussion as some users wanted to see only terms closely associated with both of the central terms, while others wanted the union of all similar terms.

In one exciting interaction, a member of the audience wanted to do an internet search. While we were explaining that we had not yet migrated the system to the web, another audience member, misunderstanding the question, jumped into the discussion and explained (correctly!) what the application did and how the dartboard should be used.

We were extremely gratified by these reactions, as they confirmed our belief that the interface is very intuitive, and thus especially useful for casual searchers.

4.2 Evaluation Methodology

While the response to our demonstration was rewarding after a long summer's work, we are not satified with merely providing anecdotal evidence of the effectiveness of our system. Thus we plan to undertake a formal usability study in the fall of 2004. Our approach will mirror other formal studies of visualization systems, such as the one described in [11].

4.2.1 Data set and Topics

We will use all or part of the federal register data from TREC disk 4 as our collection to be searched. We will use the Parallel General Text Parser (PGTP) tool to extract the words from the collection, produce the term by document matrix, and compute the SVD of the term by document matrix.

We will pose as queries a subset of the topics from the TREC-6 Interactive task. These topics are described in Table 1.

4.2.2 Test Subjects

We plan to solicit test subjects from among the student body at a small liberal arts college. We will restrict the number of computer science majors who participate to less than 25%, if possible. We plan to split our subjects into three groups. The first group will have access to a text based traditional vector space retrieval system only. The second group will have access to the same traditional vector space retrieval system plus the dartboart visualization tool. The third group will have access to the text based system during the first half of the experiment, and will be given access to the visualization system during the second half of the experiment.

A key component of our evaluation is that we will offer no training to the test subjects. If asked for assistance in understanding the tool, we will decline to respond and reiterate the nature of the experiment.

Each subject will be asked to give no more than 60 minutes of his/her time for the experiment. In addition, the topics will be randomly assigned to different subjects. Each participant will be allowed at most 15 minutes to complete the search for each topic. Thus, each participant will have the opportunity to evaluate the interface(s) on four or more topics.

4.2.3 Metrics

A pre-experiment questionaire will be provided to each participant. In addition to demographic information, participants will be asked to rate their ability at completing internet searches and their general technical knowledge.

Subjects will be asked to complete a questionaire at the conclusion of each topic search. Users will provide data pertaining to the search itself, such as the topic, the answer(s) and the amount of time spent on the topic. Users will be also be asked to rate the difficultly of the topic, and the usefulness of the search tool. Furthermore, users with access to the visualization tool will be asked if they used the tool, what features they used, if they felt that the visualization provided meaningful assistance.

A post experiment questionaire will be given to subjects with access to the visualization tool. On this survey, participants will be asked open ended questions about the interface design, and will also be asked to provide suggestions for improving the interface.

5 Summary

Existing search tools frequently frustrate users. This project focuses on the development of a visualization tool to assist with user-driven query refinement. We have described our dartboard image for identifying terms which might be helpful for query expansion. We have taken particular care to ensure that the visualization we provided was both intuitive and powerful, and that the tool gives the user complete control of the topic search.

We have provided a summary of the user feedback we obtained from a system demonstration. The informal feedback we received supports our assumption that our system in intuitive. We plan to complete a formal usability study in the fall of 2004. The results of that study will be available for the final version of this paper.

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