Auditory WWW Search Tools

Alex Ferworn
School of Computer Science
Ryerson Polytechnic University
350 Victoria Street
Toronto, ON, M5B 2K3, Canada
+1 416 979-5000 x6968
aferworn@acs.ryerson.ca

Richard Bodner
Personification Inc.
151 Bloor Street W., Ste 820
Toronto, ON, M5S 1S4 Canada
+1 416 324-9233
rick@personification.com

Mark H. Chignell
Personification Inc. and
Knowledge Media Design Institute
University of Toronto
+1 416 324-9233,
mark@personification.com

ABSTRACT
Early Web applications were overwhelmingly visual. As the Web becomes an essential tool in knowledge work, electronic commerce, and virtual interaction, there is a need for auditory interfaces to Web applications. Such interfaces are particularly important for people with visual disabilities and print impairment, and for people who want to listen to information while their eyes are occupied elsewhere (e.g., in navigating through an environment). In this paper we describe the design and testing of an innovative auditory search engine. This search engine provides its output in a more aural-friendly format by using real-time text categorization to organize search results into a voice menu format. Initial results show that the auditory search engine prototype works well for partially sighted, and sighted users.

Keywords
Accessibility; universal access; auditory interfaces; search engines; visual disabilities.

INTRODUCTION

This paper describes the design and development of an auditory search engine. This work was motivated by a need to provide a non-visual web-interface for people with visual disabilities and print impairment who wanted to search the World Wide Web (WWW). Our long-term goal is to describe, design and provide a set of information and knowledge management tools that open a world of information to the visually impaired and to others who need auditory access to textual information. In this paper we present work undertaken at Personification Inc. to provide an auditory WWW search engine for the blind. This work was conducted in partnership with the Adaptive Technology Research Centre at the University of Toronto, and with Extend Media Inc.

In the first part of the paper we present a brief overview of the technologies commonly available for auditory access of large information spaces, their benefits and limitations. Following this we provide an overview of how our prototype auditory search engine works. We then review the results of a user study and discuss plans to extend the prototype into a fully functioned auditory search engine.

ACCESSIBILITY INITIATIVES

The difficulty with the Web is that it was designed and implemented predominantly by those who can see. This is a significant problem for the visually impaired. It is also a problem for mobile users whose eyes are occupied elsewhere, or who have only a small screen (e.g., on a mobile phone) available to them.

While the availability of Internet bandwidth increases daily, the bandwidth of information that people can sense or perceive is fixed by their individual capabilities and by the tasks they perform in particular contexts. People with visual disabilities and print impairments have to rely on auditory playback of Web information through screen readers and auditory Web browsers. Such playback is problematic because the pages themselves have not been designed for auditory access, but for presentation in a graphical user interface. The hyperlinks that exist between various Web pages take no account of the requirements that people with auditory browsers and screen readers have. Furthermore, conventional (visual) search engines translate poorly when converted to sound because there is no auditory equivalent to quick visual scanning of a list of hits from a search engine. There is a strong unmet demand for tools and services that can carry out searches and organize the resulting information on a topic in such a way that it can be conveniently played back via spoken text.

Accessibility means providing flexibility to accommodate an individual's needs and preferences. In the context of the Internet, accessibility implies making computer technology and Internet resources useful to more people than would otherwise be the case. To a large extent the WWW can be made more accessible by following simple guidelines, but the majority of Web pages and services do not yet follow those guidelines that are available.

There are numerous resources on the WWW encouraging web site developers to make their sites accessible. Relevant documents include reports from the TRACE institute [8], and from not-for profit organizations that are concerned with services for people with visual disabilities and print impairments, such as: The Society for Reading for the Blind and Disabled [7]; The Daisy Consortium [2]. Numerous books and papers speak to this issue, notably the National Research Council (NRC) report, "More than Screen Deep" [5].

In 1998, the World Wide Web Consortium (W3C) launched the Web Accessibility Initiative (WAI) [11]. One of the results of this work was the development of Page Authoring Guidelines, which reflect the accessibility improvements in the "HTML 4.0 Recommendation". The W3C also offers an HTML Validator Service [9] to help developers become accustomed to addressing accessibility issues. Other attempts to improve accessibility have focused on a form of advertising such as the "4-star Bobby Approved!" [1] emblem as promoted by the Center for Applied Special Technology (CAST). CAST is a non-profit organization whose mission is to expand opportunities for all through innovative uses of computer technology. The Web Access Project of the National Center for Accessible Media (NCAM) [4] allows sites to display its web access symbol if reasonable effort is made to comply with WAI Page-Authoring Guidelines. Commercial software developers are also working to add features to browsers and accessibility validators to HTML editors. More information concerning these efforts can be found at WebAble [10].

Another approach has been to take the web content that has been produced and convert it into a blind-friendly format. This inevitably involves the removal of graphical elements and structural reorganization. This is the approach taken by so-called "Web Access Gateways" (WAGs)[1]. WAGs typically serve two purposes, to make the Web easier to access for the visually impaired, and to allow non-English speakers to view Web pages in their own language. WAGs attempt to intercept pages destined for a user's web browser and rearrange them before they are displayed. In general, this syntactic solution works with all commercial browsers and operating systems as long as the browser supports HTML "forms".

Briefly, each of these accessibility initiatives attempts to deal with informational issues either by placing the onus on a site developer to provide access or by performing modifications to existing pages based on syntactic interpretation and conversion. Our approach is markedly different. We have provided a search and retrieval tool accessible as a portal on the WWW expressly designed to facilitate information retrieval by non-sighted users or by users who choose to use an auditory interface for convenience or to meet particular task requirements.

ACCESSIBLE SEARCH

Search engines have become an essential tool for finding information on the Web efficiently. Like other Web users, people with visual disabilities and print impairment need easy access to relevant and up to date information. These users need specialized search tools to help them deal with search results effectively when presented through an auditory interface. It is tedious, if not impossible, for these users to scan long lists of results using an auditory interface (i.e., playing these results in an unbroken, inflexible, and tedious sequence). We have chosen to employ a "divide and conquer" approach using categorization to address this issue.

Rather than provided long lists of hits that can be scanned visually but have to be heard one at a time in linear fashion, targeted channels of information allow more efficient browsing using an auditory interface. Our search engine prototype develops targeted information channels based on queries made against a database of press releases. A demonstration of the prototype is available at www.eyesfree.com.

AUDITORY SEARCH ENGINE ARCHITECTURE

This section describes the architecture of an auditory search engine for the visually impaired. The search engine collects the user's query, runs the query against the database, aggregates and filters the results, and then extracts the text from the set of returned "hits". This text is then indexed and organized into a hierarchical structure, with summaries and previews. The resulting structure is then dynamically marked up as a hierarchical set of Web pages, suitable for playback on existing auditory Web browsers. The results set for a given query is retrieved and organized in a three phrase process as described in the next sections.

Phase 1: Search Engine

In the first stage we use a conventional search engine to find a small subset of appropriate information from a given data collection. Although we currently use own our search engine for the prototype system based on the vector space model [6], it is possible to incorporate other search engine technologies, including a meta-search technique (i.e., aggregating the results for

---

[1] Various WAGs can be accessed from http://epona.ucam.org/~ssb22/access.html

numerous search engines). In the future, the use of a meta-search technique would allow more effort to be placed on the second phase of the system while allowing for increased coverage of the information available on the WWW.

Phase 2: Clustering

The second phase of the process takes the search results obtained and clusters them using a modified version of a text clustering algorithm (see [3] for an overview of clustering algorithms). The results are organized into hierarchy of topics, sub-topics, and articles.

Keywords and key phrases are used to label terms for the topics and sub-topics. The terms used in the labels are generally the most important (or relevant) terms in the cluster, based on automated indexing techniques (see [6] for a more detailed discussion).

The order of appearance for the articles in the topics and sub-topics lists is based on the estimated relevancy score for the article to the user's query. Thus the list is ordered from the most to least relevant articles. Furthermore, the topics and sub-topics are also organized based on an aggregate relevancy value. Again, sub-topics that are more relevant appear higher in the list.

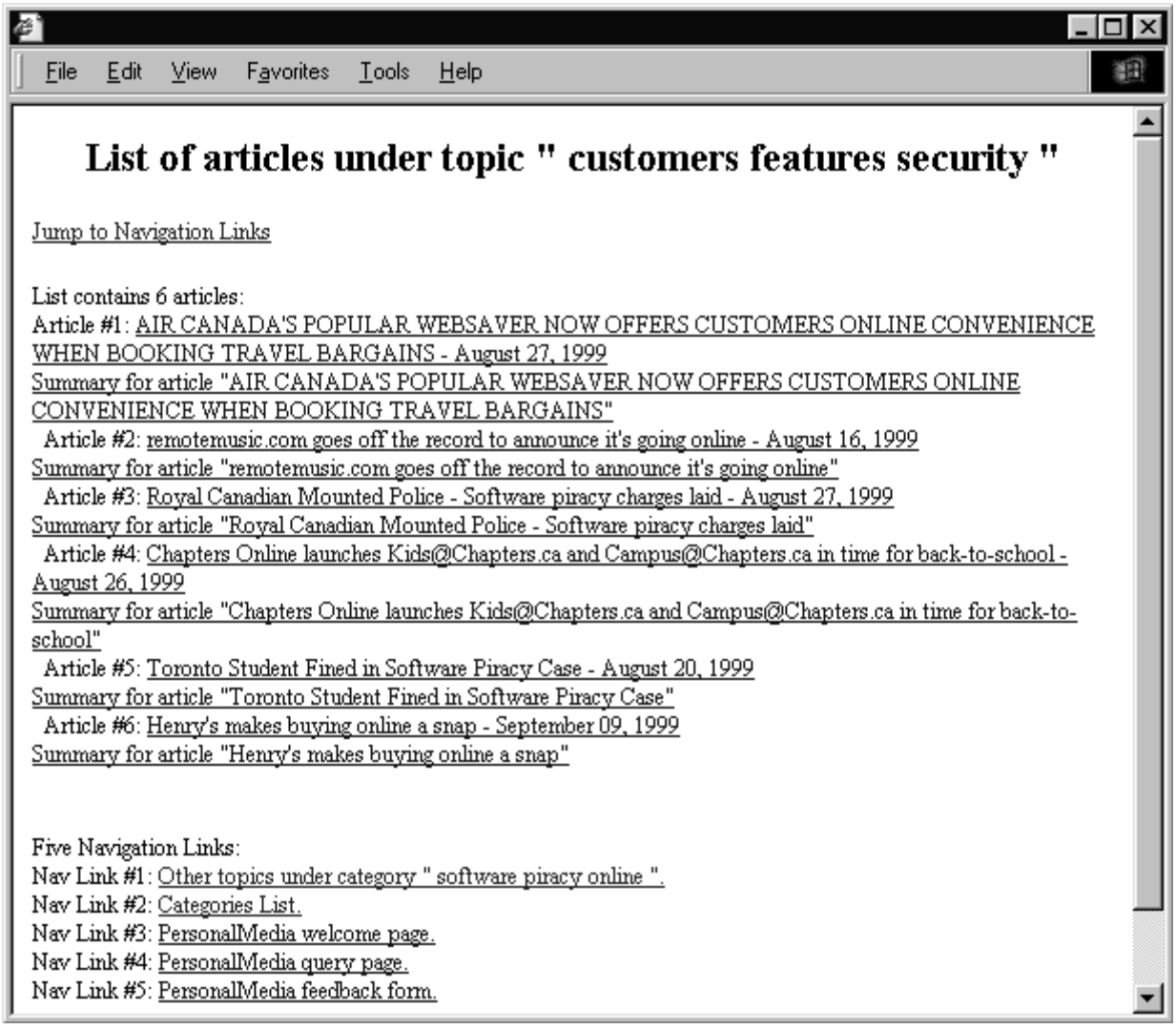

Figure 1. Article listing for the topic "software piracy online". The initial query was "computer security".

Phase 3: Dynamic Web Page Creation

The final phase is the process of creating the pages of organized articles based on the clustering information. Some general conventions are used throughout the pages to assist the auditory user to easily navigate the topics and articles. The

conventions used are:

- Navigational links are at the bottom of the screen with a link at the top of the screen which allows the user to jump to the navigational links
- All lists state, in the title, the number of items that appear in the list
- Each list item has a meaningful label that reminds the user of list subject and of its position within the list.
- At the bottom of each Web page, there is a link to jump back to the top of the Web page.

The lists on the topic and sub-topic pages contain label terms identified in the clustering phase. Along with the terms, the link label also contains the number of sub-topics (when appropriate) and the number of articles that the user could retrieve by following the link.

The sub-topic page displays a link to the complete article. The link label is the title of the article. There is also a second link for each article, which is a link to a summary of the article. Currently, we provide the "lead paragraph" of an article as the summary for the press releases (Figure 1 shows a sub-topic article listing for the query "computer security"). We have also created an automated process that identifies important sentences in articles and then organizes these sentences into a meaningful summary. This process will be used in future versions of the system. Figure 2 shows the output from that summarizer when run on the conclusions section of this paper. Note that only the simplest/shortest summary is generated for this example; the summarizer can generate longer summaries. A demonstration of that summarization process can be found at ***www.textsummary.com***.

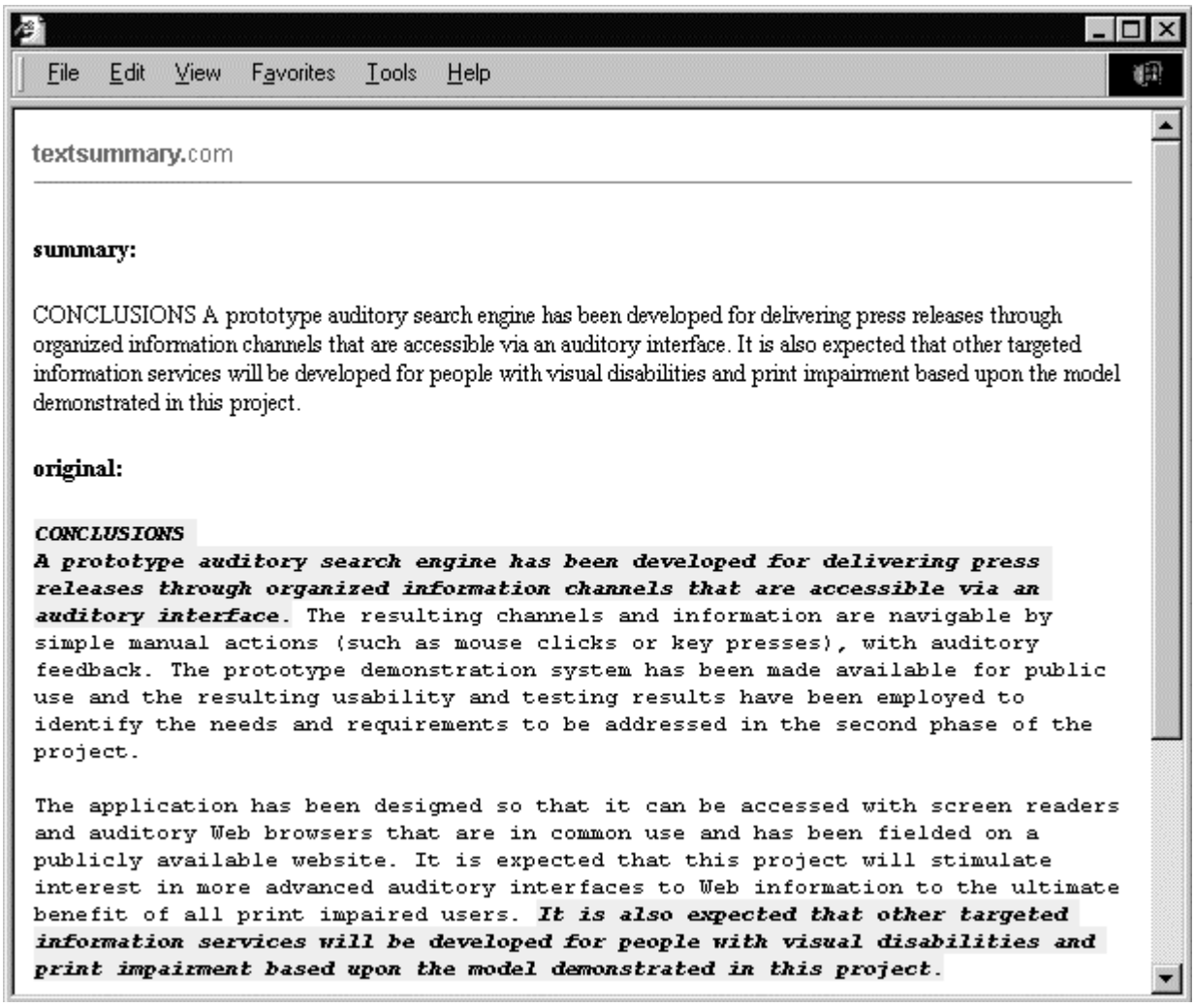

Figure 2. The result from running the summarization process on the conclusions section of this paper.

USER STUDY

The search engine is based on a set of technologies that organize search results. Simple keystrokes (the arrow and enter keys) are used to control the auditory playback of information, including channel selection, skipping between information items, and moving between summary "lead paragraphs" and corresponding "full stories". The output of the search engine is an accessible Web site that is designed to be played back with whatever browsing and screen reading technology is preferred by the user.

The prototype system was evaluated independently by usability experts and by a group of people with visual disabilities and print impairment. The test group was solicited through the Skyclub mailing list that is run by Canadian National Institute for the Blind (CNIB) personnel and through contacts provided by the Adaptive Technology Research Centre at the University of Toronto.

The results of the evaluation were generally favourable. Users felt that the divide and conquer approach to information search was a good one, but that further work was needed to improve the categorization and labeling process and to rank order the categories according to relevance. Users also wanted more and varied content to test the prototype. Overall, however, it appeared that there was considerable demand for timely delivery of organized channels of information that people with visual disabilities and print impairment could use more easily, without having to rely on intermediaries. Some specific issues encountered in the user study are summarized below.

Sparse Context

Queries often returned few relevant documents. This is an ongoing problem related to our sparse database. We are addressing this issue by using a much larger database and/or by providing more general and powerful search engine functionalities.

No Results

In cases where no results are returned we added a hypertext link in the navigation section of each page directly back to the search page.

Relevancy of Results Set

Due to the restricted scope of our content database, users were often unable to find results of interest to them. Instead, they tend to find loosely related information of little or no interest. We are addressing this issue by using a web-bot to gathering new content. In addition, we are investigating a meta-search technique that will allow the prototype system access to the content of other popular search engines available on the WWW.

Speed

Initially, our search engine was quite slow in comparison with other conventional search engines (e.g., Alta-Vista, Yahoo, Google, etc.). We addressed this problem through programming and algorithmic efficiencies, which improved our performance by almost an order of magnitude.

Integration with Existing Tools

We are in the process of improving our dynamic Web page creation phase so that it closely follows the requirements of popular Web page reader software (e.g., PWWebspeak). As noted earlier, we will need to address the issue of how to facilitate the use of different Web browser and screen reader technologies. This is in fact a moving target as new technologies and solutions come to market.

CONCLUSIONS

A prototype auditory search engine has been developed for delivering press releases through organized information channels that are accessible via an auditory interface. The resulting channels and information are navigable by simple manual actions (such as mouse clicks or key presses), with auditory feedback. The prototype demonstration system has been made available for public use and the resulting usability and testing results have been employed to identify the needs and requirements to be addressed in the second phase of the project.

The application has been designed so that it can be accessed with screen readers and auditory Web browsers that are in common use and has been fielded on a publicly available website. It is expected that this project will stimulate interest in more advanced auditory interfaces to Web information to the ultimate benefit of all print impaired users. It is also expected that other targeted information services will be developed for people with visual disabilities and print impairment based upon the model demonstrated in this project.

In order to build on this work and to extend the value of these results, we are creating a portal for people with visual disabilities and print impairment, and for eyes-free and small-screen equipped mobile users (***www.eyesfree.com***). This portal site will include a comprehensive search engine, in addition to features that will allow the category structure to be personalized to each individual's needs and interests. This will allow us to leverage the innovative technologies developed in this project into a broad-based information access solution for people with print impairment and related disabilities.

ACKNOWLEDGMENTS

We would like to thank Networks Ontario for their support of this work through the Telecommunications Access Partnerships (TAP) programme. Special thanks go to James Stirling, Jutta Treviranus, and Keith Durrant for their assistance in implementing this project, to Karen McCall for her usability engineering work, and to personnel at the Canadian National Institute for the Blind Library for their assistance in identifying potential users, and for their advice concerning auditory Web browsing and screen reading technology.

REFERENCES

1. Bobby, http://www.cast.org/bobby/
2. The Daisy Consortium, http://www.daisy.org
3. Everitt, B.S. *Cluster Analysis* (1993) Third Edition. London: Edward Arnold.
4. National Center for Accessible Media, http://www.wgbh.org/wgbh/pages/ncam/currentprojects/wapindex.html
5. National Research Council. *More than screen deep: toward every-citizen interfaces to the nation's information infrastructure* (1997) Washington, DC: National Academy Press.
6. Salton, G. *Automatic text processing: the transformation, analysis, and retrieval of information by computer* (1989) Reading, Mass.: Addison-Wesley.
7. The Society for Reading for the Blind and Disabled, http://www.rfbd.org
8. The Trace Institute, http://www.trace.wisc.edu
9. W3C Validator Service, http://validator.w3.org/
10. WebAble, was www.yuri.org
11. World Wide Web Consortium Accessibility Initiative, http://www.w3.org/WAI/