Usability of Web Search Interfaces for Blind Users – A Review of Digital Academic Library User Interfaces

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Abstract. In this paper we report our findings on the usability of four digital academic library databases when used by blind individuals using a screen reader. Our interaction level analysis shows that despite improvements in accessibility guidelines and technologies web search interfaces still lack good usability for screen reader users. Accessibility issues appear to have been addressed from the angle of technical readability instead of usability or user experience. As a result of the analysis we present design suggestions for making a web search interface more usable for screen reader users: 1) Highlighting search results (e.g. using headings), 2) No unnecessary elements before search results, 3) Search edit field and button in the beginning, 4) Descriptive labeling of search elements, 5) Abstract right after the search result title.

Keywords: accessibility, usability, screen readers, web search, user interface.

1 Introduction

Digital academic library databases (DALD) are standard and everyday tools for researchers and students. Without these, efficient research work is not possible anymore. Therefore, many academic and research institutions have provided gateways and access to these databases as part of the modern offering of their library services. The access to these databases is, however, not straightforward and consistent between different database providers and publishers. The search interface is the key element in providing a smooth user experience for the users of the databases and services.

Modern search interfaces are widely considered easy-to-use. However, this is not the case with all users. Even though 92% of sighted users share this easy-to-use experience, only 7% of the non-sighted users agree with this (Buzzi et al. 2004). Therefore, in addition to the visual appearance of the search interface, the invisible screen-reader accessible structure is similarly important.

In this paper, we analyze the usability of search interfaces for non-sighted persons using a screen reader. We have analyzed the user interfaces of four popular DALDs emphasizing not just accessibility but also usability. At the end of the paper we outline suggestions for screen-reader-friendly search interfaces.

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2 Concepts and Related Research

2.1 Using Screen Readers

Screen readers are software tools that enable visually impaired and blind individuals to use a computer. A screen reader interprets the visual content on a display and describes this information to the user using synthesized speech. The content is read to the user in a serial manner so that a user only interacts with one element at a time.

A sighted user can scan the page quickly to get an overview of the page structure and find the relevant content quickly. However for a non-sighted user this is usually a major challenge and can be a time consuming and frustrating process. (e.g. Rakesh et al., 2009; Lazar et al., 2007; Di Blas et al., 2004)

A screen reader user uses the keyboard to interact. Screen readers have several different keyboard commands that enable more efficient manners of interaction. On a web page the screen reader starts to read the page from the beginning (i.e. from the top left corner of the display). This is not a very efficient way of reading considering the amount of irrelevant content a single page typically includes. However the user does not need to read every single element on a web page. Screen readers allow users to use keyboard commands to browse through and jump over different elements. A blind individual can, for example, go through all the links, headings, lists, tables, form fields, edit fields, and graphic elements of a web page. This makes browsing a web page and accessing relevant and interesting content more efficient.

WebAIM (2012) conducted a survey of 1782 screen reader users in 2012. The study showed how differently screen reader users browse the web stating that - “there is no typical screen reader user”. This can be a major design challenge for web developers trying to make their sites not only accessible but more usable for screen reader users. In this paper we aim to bridge this gap through analyzing the use of search interfaces with screen readers from the usability viewpoint.

Screen reader users mentioned to try navigating through headings (60.8% of the respondents) first in order to find information (WebAIM (2012). Navigating through links was mentioned by 13.2% of the respondents. Landmarks were used by 2.3%.

2.2 Accessibility

Accessibility can be considered as “reachability”. Accessibility enables the non-sighted users to access and use the website or service mainly from the technical viewpoint. Accessibility ensures the “technical readability” for the non-sighted users. However, this is not a sufficient level of operation for optimal efficiency. In a study by Christopher et al. (2012) only 50.4 % of all the problems that non-sighted users encountered were addressed by Success Criteria in the WCAG 2.0. In order to achieve the more advanced levels of usage, we need to address both usability and user experience of the service when used with a screen reader (e.g. Buzzi et al. 2004; Di Blas et al. 2004 & Byerley et al. 2005).

2.3 Usability

Usability has been defined in ISO 9241-11 standard (1998) as "the extent to which specified users can achieve specified results with specified effectiveness, efficiency, and satisfactions". In addition to this definition, some research-originated definitions of usability are widely used, namely the one published by Nielsen (1993). We use the following integrated metrics from both of these definitions while reviewing the four web search interfaces:

Effectiveness – Are the basic search tasks technically achievable using a screen reading software?

Learnability – How efficient is it for the user to perform basic tasks successfully at the first time?

Efficiency – How quickly can a user perform tasks after learning to use the search interface?

Memorability – How efficiently can a user use the search interface after not having used the service for a while?

Satisfaction – How pleasant is it to use the search interfaces?

2.4 Search Engine Interfaces Used with a Screen Reader

Research has been done on search engine interfaces and how they can be accessed using a screen reader (Buzzi et al. 2004, Leporini et al. 2004A, Leporini et al. 2004B Andronico et al. 2006 and Ivory et al. 2004). The challenges of these interfaces are very similar to those when browsing any other web page – i.e. navigating and finding relevant and interesting content on a web page efficiently. In a survey by WebAIM (2009) Google was the "favorite web site" among screen reader users. This was for all web sites and not just for search engines.

Most screen reader users do not believe that search engines are easy-to-use (Ivory et al. 2005). In a study by Buzzi et al. (2004) only 7% of non-sighted users felt that search engines are easy-to-use. In comparison 92% of sighted users considered the same search user interfaces easy-to-use. For non-sighted users it was harder to find the information they were looking for. Reading the additional information provided for each search result is also harder for non-sighted users (Ivory et al. 2005).

Leporini et al. (2004A) have set some instructions on how to design a more usable search engine interface for screen reader users. Below are listed the guidelines that are the most relevant regarding our review and the tasks we conducted on each DALD:

1. Search elements such as search fields and buttons should be labeled correctly and placed at the top of the page. This makes accessing them more rapid.
2. The result area should be highlighted using a heading before the results.
3. The search results should be placed in a numbered list so that each list item is a link to the result. Also a summary of the result should be placed here. The results list should be placed just after the result notification.

3 Our Study: Analysis of Four Search Interfaces

A search task was performed for four different DALDs: IEEE Xplore, ACM, Scopus and Google Scholar. The search term used was "user experience" in order to ensure a vast amount of search results. The aim of this was to find out how a non-sighted individual can find relevant and interesting information (e.g. research articles) from these databases. Table 1 presents the four tasks that were conducted on each of the four digital academic library database.

Table 1. Tasks performed for each DALD

Task #	Task description
1	Performing a simple search: This included finding the search elements (i.e. search edit field) from the site and performing a simple search. The search term used was "user experience".
2	Finding the title of the first search result: This task included finding the first search result from the results page.
3	Browsing the result titles one-by-one: This task included going through the titles of the search results one-by-one. This task was performed after the user had navigated to the title of the first search result.
4	Accessing and reading the additional information: This included accessing and reading additional information about a search result. This was done in the result page without having to leave the page. All sites provided at least the following information: authors, publisher, publication year and a short summary or the abstract of the search result. This information was displayed below the title.

The review was done by one non-sighted and skillful screen-reader user. The analysis includes a low-level description of the interaction a non-sighted individual is required to do in order to complete the four basic tasks. The screen reading software tells the number of headings and links of a web page automatically after a page is loaded. This information is presented in this paper as well.

We applied the most used methods of navigating a web page described in the WebAIM (2012) survey to the web search interfaces we reviewed. These methods were only used for browsing the search results (tasks 2 and 3). Task 4 was accomplished using the down arrow key and spacebar if links had to be opened in order to complete the task successfully.

The review was conducted using Microsoft Windows 7 operating system and Internet Explorer 9 web browser. The screen reading software used, was JAWS (version 13.0.1006) by Freedom Scientific. These were chosen since they are all the most popular among screen reader users (WebAIM, 2012). Other assistive technologies such as braille displays were not used in this study.

Leporini et al. (2004A) and Leporini et al. (2004B) suggested the use of list elements displaying the search results. For this reason we used lists as well when trying to navigate the web search interfaces. We also tried to find the most efficient way (i.e. least amount of keystrokes – inputs from the user) of doing the four tasks described. The number of keystrokes needed by a user was recorded for each method and search interface. We start from the assumption that the number of user inputs correlates straightly to learnability and efficiency. Subjective satisfaction is affected by these two (Lazar et al. 2007).

In our study, the DALDs were accessed through the gateway of the Aalto University library which provides a full-text access to all the analyzed databases. The search user interfaces may vary if accessed through other gateways and proxies.

3.1 ACM Digital Library

After loading ACM Digital Library (ACM) the screen reader informed that there are 48 links and no headings on the first page. On the first page there is only one edit field that did not have a label indicating that what it is used for. After the edit box there is a button that is labeled “Search” that made the purpose of the edit field more apparent. After this performing a search task was accomplished easily.

The first results page contained 171 links and no headings. The search results were not highlighted as headings or as a list. Therefore, at the first time it was only possible to find the first result by going through links). This required 43 keystrokes since the 43rd link on that page was the title of the first search result. Navigating to a next search result through links required at least 3 keystrokes depending of the additional information (e.g. number of authors) between two result titles.

After getting more familiar with the site structure it came apparent that the search results are actually presented inside a table. The search result titles and other additional information about the result were presented on the second column. After this it was possible to browse the search results in a more efficient manner - requiring total of 5 keystrokes accessing the first search result and 3 keystrokes navigating to the next search result. (Navigating inside a table between columns requires three keys to be pressed simultaneously on the keyboard.)

Accessing the short summary of a search result required 10 keystrokes.

3.2 Google Scholar

The search page of Google Scholar had 13 links and no headings. After loading the page, the screen reader activated the edit field (apparently the Search box) automatically. The edit field did not have a label. The next element after the edit field was a link to advanced search and the element after that was a search button.

After performing a simple search the search results page contained 10 headings and 108 links. Each search result was highlighted using heading tags. This made it possible to navigate to the first search result and browse the titles of the search results one-by-one using just the ‘H’ –key on the keyboard. By default 10 search results were displayed per search result page. In the results page there were 3 lists as well. These lists contained sorting and filtering elements for the search results.

After the result title, authors and publisher, a short description including samples of the article was presented. Accessing this information required 3 keystrokes.

3.3 Scopus

The first page of Scopus contained 50 links and one heading. The only edit field on that page was activated automatically by the screen reader. The edit field was labeled “Search term”. The search button was the fourth element after the edit field.

The first search result page contained 269 links and 1 heading. The search results were not highlighted using headings or lists. For this reason the first result on that page was found by going through links. This required 43 keystrokes. Browsing through all of the links one-by-one it was possible to find the next results as well. This required 7 keystrokes.

We were able to find a more efficient way of finding the first search result by first navigating to the first combo box on that page (the ‘X’ –key), then navigating to the next check box (the ‘C’ –key) and then pressing the down arrow key twice. Navigating to a next search result could be done similarly without navigating to a combo box. This method reduced the number of keystrokes needed and made performing tasks 2 and 3 more efficient.

After each result title there was additional information regarding the result. It was possible to open the full abstract on the same page without having to leave the site. This required 16 keystrokes. There was also a link to show all the abstracts of each search result which revealed abstracts’ of each search result displayed.

3.4 IEEE Xplore

The first page of IEEE Xplore contained 61 links and 7 headings. On this page there was only 1 edit field which was labeled “Search term”. After the edit field was the search button.

On the first result page there was 326 links and 34 headings. Each search result was highlighted and tagged as headings. The first result was the fourth heading on that page. Finding the first search result in this site required 4 key strokes. Browsing to the next search result required 1 key stroke.

The full abstract of a search result could be opened in the results page. This required 22 keystrokes. This way the user did not have to leave the results page in order to read the abstract from another page.

4 Analysis

All of the web search interfaces reviewed performed very different from each other using a screen reader. All sites had their advantages and disadvantages. All of the databases reviewed were technically accessible – i.e. they all could be operated using a screen reader.

A challenge users of a screen reader typically face is finding the relevant and interesting content in a web page. Navigating to the first search result and browsing through the rest of the results showed some major differences between each site in terms of usability.

Google Scholar and IEEE Xplore highlighted each search result with a heading tag. This made finding the search results and browsing the result titles extremely efficient since the user can navigate to the next result by just pressing one key on the keyboard.

Accessing the short preview of a search result showed some differences in terms of efficiency and the method this was accessed. ACM and Google Scholar displayed a short preview of the abstract and article. Scopus and IEEE Xplore provided a link that revealed the whole abstract. The abstract on these both sites opened on the same page. This is not as efficient but the user accesses the whole abstract this way without having to leave the search result page. Accessing the full abstract from Google Scholar or ACM requires leaving the result page and finding the abstract from another page which can be a time consuming process. Scopus also provides the user a possibility to show the abstracts of all the results in the results page.

Table 2 presents the number of keystrokes a screen reader user is required to do in order to find the first title of the first search result from the results page. This was done from the top of the page. The methods used are presented in the first column. We tried navigating through headings, links, landmarks, and lists. None of the sites used landmarks to present the search results area. IEEE Xplore was the only page that could have been operated using lists. However, the screen reader used read the list items in an almost non-understandable manner because the highlighting of the search term in each search result corrupted the fluent screen reading. Due to this, lists are excluded from this review.

Table 2. Number of keystrokes required for navigating to the title of the first search result

	ACM	Google Scholar	Scopus	IEEE XPlore
Headings	N/A	1	N/A	4
Links	43	21	43	43
Optimal	5 (second row and second column of the first table on the page)	1 (first heading on the page)	4 (first combo box, next check box and pressing the down arrow key twice)	4 (using headings)

We also tried to find the most optimal method of performing tasks 2 and 3. The optimal method in this review presents the most efficient way (i.e. least amount of keystrokes needed) of browsing through the search results. Finding the most efficient method took time and effort since the page's structure and its elements had to be studied first.

Table 3 presents the number of keystrokes a screen reader user has to do in order to get to the next search result from another search result. The methods used are presented in the first column.

Table 3. Number of keystrokes required when navigating search result titles one-by-one

	ACM	Google Scholar	Scopus	IEEE Xplore
Headings	N/A	1	N/A	1
Links	3	7	7	10
Optimal	3 (Ctrl + Alt + Down arrow key)	1 (headings)	3 (combo box -> 2 x down arrow key)	1 (headings)

Below are the results for the usability of each web search interface.

Effectiveness – For the four tasks presented in this paper we found that each web search interface was technically accessible for a blind user using a screen reader. In practice this means that all the tasks could be accomplished despite the time it took to learn and master the DALD search user interface.

Learnability – We consider learnability as the efficiency of interaction when using the DALD for the first time. Finding the first result on the result page and browsing through the results one-by-one showed some significant differences in terms of first-time use efficiency. Going through headings is by far the most used method to navigate a web page by screen reader users. Google Scholar and IEEE Xplore were the only search interfaces that used headings to highlight result titles. These search interfaces were the most efficient when using them for the first time considering that the user expects to find relevant information through headings in the web page. Another method some screen reader users use to navigate a web page is going through links one-by-one. Using this method Google Scholar was the most efficient one.

Efficiency – After having learned the structure of a DALD user interface, the most efficient services in tasks 2 and 3 were Google Scholar and IEEE Xplore. However, after using ACM and Scopus and investigating the structure of the result pages it was possible to find much more efficient workarounds to accomplish tasks 2 and 3.

Reading a short preview of the full text provided below the result title on the result page could be accomplished most efficiently with Google Scholar (3 keystrokes) and ACM (10 keystrokes). Scopus (16 keystrokes) and IEEE Xplore (22 keystrokes) provided the user an option to reveal the whole abstract on the results page which could not be accomplished as efficiently. However, using this method the user does not have to leave the search results page and navigate to the full abstract in another page. For accessing the full abstract Scopus and IEEE Xplore were the most efficient.

Memorability – Google and IEEE use headings for navigation. This supports good memorability. The workarounds that were found for Scopus can be forgotten easily. The most efficient method finding the first search result in Scopus required the user to navigate to the first combo box, then to the next check box and after this pressing the down arrow key twice. ACM uses a table for the search results. This requires the user to navigate to the first table and then to the second row and second column of that table. These methods of navigating a web page when trying to find interesting and relevant information are not used by screen reader users typically (WebAIM 2012).

Satisfaction – Lazar et al. (2007) found in their research that the time lost frustrates screen reader users when trying to accomplish a task. For tasks 2 and 3 Google Scholar and IEEE Xplore can be considered the most pleasant to use.

For accessing a short summary of a search result Google Scholar and ACM were the most pleasant to use (i.e. they were the most efficient). Even though IEEE Xplore and Scopus were not as efficient, they provided a possibility to read the full abstract without having to leave the page, For a user who wishes to read the full abstract and not just a short summary, IEEE xplore and Scopus are the most efficient and therefore the most pleasant to use for this.

5 Conclusions and Discussion

Based on the results of our review with the basic search tasks we present following suggestions on the design of usable screen-reader-accessible search interfaces:

1. Highlighting each search result – Finding and browsing through the search results can be a burdensome and time consuming task. We suggest that every search result would be highlighted as headings on the search results page. There should be none or only a few headings before the first search result.
2. Reducing the number of unnecessary elements before the search results - Many screen reader users browse through links or read through the whole web page in order to find interesting and relevant information and content. For this reason the number of links and other unnecessary elements before the first search result should be minimal so that the search results could be accessed more rapidly.
3. Search elements first - The search elements (i.e. search edit field and button) should be placed at the top of the page – preferably they should be the first elements on that page.
4. Descriptive labeling of search elements – All of the search elements (e.g. search fields and buttons) should have a label indicating for what the element is used for.
5. Abstract below the search result title – Each search interface we reviewed provided a short preview of the full text or the whole abstract. This information should be presented just after a result title for a quicker access. Preferably the user should be able to access the full abstract on the results page. This eliminates the need of finding the abstract from another page and thus providing a more efficient method of finding interesting information for the user.

For designing usable search interfaces developers must understand how blind users navigate the web with screen readers. For sighted users, the visual appearance of different search pages may be identical even though the structure to produce the layout varies a lot – which is faced by the non-sighted users. These structural inconsistencies between the search interfaces create additional barriers that do not support learning across sites. Our results point out the need for structural consistencies between search user interfaces so that also screen readers interpret the sites similarly.

Despite many constraints, however, even larger amount of content in a search results page does not necessarily decrease the efficiency of the page if the page is structured correctly. For example displaying the full abstract for all the results in a page would not make the page less efficient to use for a screen reader user since the user does not have to interact with every single element on a web page.

Improving the search interface of the DALDs to better serve a non-visual user using a screen reader would not require major changes to the site structures and the visual appearance would not be affected greatly. We argue that these improvements would enhance the usability – and even the user experience – of these search interfaces for non-sighted individuals.

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