This paper is concerned with ergonomic design for access to the World Wide Web for blind or visually impaired users, including the growing number of elderly, who need to access information and for whom the visual nature of the World Wide Web poses enormous problems.

We have built a Web browser named BrookesTalk which reads out the Web page in word, sentence and paragraph mode and offers different views of the page to simulate 'scanning' of its contents. The paper describes the conceptual models people use to scan the Web and how they are supported for blind and visually impaired users by BrookesTalk.

**Introduction**

This paper describes a speech output Web browser named BrookesTalk built at Oxford Brookes University which supports scanning of the Web for information. It reads out the Web page, using speech synthesis, in word, sentence and paragraph mode and offers different views of the page to simulate 'scanning' of its contents (details on http://www.brookes.ac.uk/speech) It also offers a configurable text window for visually impaired users and a standard visual browser so that blind or visually impaired users can work alongside other people who can fully utilise a standard GUI.
The process under discussion in this paper is that of searching the Web for information by means of a Web search, followed by an investigation of the search results links provided in the search engine search results page. Search result links are usually to the home pages of sites where the information required may reside. Users are then required to move through the pages of the site searching for the information they require. This paper considers what it is that blind and visually impaired users need to support such a process and describes the scanning facilities provided within BrookesTalk which enable this.

Conceptual models used when searching the Web for information
The model of the workings of the search engine.
It is common knowledge that search engines do not always return results that we would expect. Their search algorithms are based on certain premises that users can only guess at and must also rely to a certain extent on the meta keywords entered by unknown authors. As a result of experience users become better at anticipating the outcome for different search engines. They begin to know what is out there and which sites will get into the results of a search and which won't.

The model of the results page of a given search engine
Sighted users can recognise where the results of the search lie on the search results page as distinct from the other extraneous material such as adverts, images and general information about the search engine. Search engines often present them in a different colour and block them up in a list structure. Despite this many sighted users were often confused by search results pages. For example some advertising links contain words from the search string and look as though they were results of the search.

The model of the Web site being visited We would not expect
to find detailed information held on the home page. Home pages can be relatively empty with a simple mission statement or logo or consist of a list of links to other pages in the site. For a largish organisation we expect to follow several links to the page where the information lies. Sites often have the structure of a hierarchical tree. Authors frequently attach the meta keywords for a whole site to the home page resulting in the search for a particular item of information within the site returning the home page. The user must then move from the home page, through other pages, to the actual page containing the information.

The model of the page Sighted users scan pages visually for information. This is a complex cognitive activity but we know that it involves picking out individual parts of the page. Sighted users look at images for clues and then the headings and links to form a concept of the information on the page before engaging with the text. On pages with a lot of dense text they scan it by picking out relevant words and sentences.

BrookesTalk support for conceptualisation of the Web Blind and visually impaired users also require the models described above in order to search the Web. The aim in incorporating extra scanning functions in BrookesTalk is to support them in developing these models (Zajicek et al, 1997). We describe below how BrookesTalk helps these users to construct models. We also describe user’s response in pilot evaluation carried out mostly at The Royal National Institute for the Blind, UK.

How BrookesTalk supports a conceptual model of the search results page. In a visual browser the results of search are presented as links on the search results page. However the page is also used heavily for advertising, containing images and links to many sites. Even sighted people find that distinguishing the links that represent the actual results of the search can be
cognitively demanding especially when the search has not returned an expected result.
Most Web browsers for the blind and visually impaired provide the facility for listing the links on a page. This way the user has the possibility of stepping through the links of the search results page trying to identify the links that actually represent the results of the search. This is often very difficult.
If the search is not particularly successful, results may be obscure and difficult to distinguish from other links. In most search engines the first link representing the actual results of a search is around number seventeen. This means that the user must listen to a lot of links before they get to the useful ones. The format of search result pages for each search engine changes frequently, so that users cannot even rely on familiarity with their layout. Without the BrookesTalk function, situations arose where users followed inappropriate links which were not actually search results, got lost and then lost the search results page and ended up performing the search again. BrookesTalk separates out the results of the search and provides a concise list containing only the search results. The list is resident in the system until another search is performed and is easy to return to even if the user has already started to follow search result links. This facility was particularly appreciated by blind and visually impaired users who had already got lost on a search results page. The normal list facility continues to enable users to access all the links on the search results page should they wish to do so.

**How BrookesTalk supports a conceptual model of a Web site** As described above, users need a conceptual model of a Web site in order to move around it searching for information. For example the structure of some sites is a hierarchical menu of links. Here you tend to find factual information in the pages that represent the leaves of the hierarchical tree. Others are frame based.
BrookesTalk provides a page summary consisting of the
number of words, headings, links, images and keywords found on a page (Zajicek et al, 1998a,1998b,1998c). This function enables blind and visually impaired people to know what type of page they are visiting thus enabling them to infer the structure of the site. For example if the first few pages of the site contain few words and many links then we can infer a hierarchical tree structure.

We found this function used frequently when moving around a site searching for information. Blind and visually impaired users were able to form a picture of the type of page they were visiting without actually engaging in the page content. For example a page containing 326 words, 3 headings, 24 links, 10 images and 10 keywords is recognisable as a small page full of links. The information sought is unlikely to be found on the page and the most useful approach at this point is to step through the links to find which page to move to next.

If for example we were searching to find the date that Braille was invented, a search on 'Braille' would lead us to the site for the Royal National Institute for the Blind. This sire is organised as a hierarchical tree and the information about Louis Braille and Braille itself are found after following six links from the home page. The page that contains the information contains 945 words, three headings and one link i.e. is very textual and an ideal candidate for the BrookesTalk abstracting function described below.

BrookesTalk provides an extracted keyword list for the page (Zajicek et al, 1998d) which can be used alongside the meta keywords provided by the author to judge the contents of a page. With experience, the juxtaposition of extracted keywords based on the text of the page, and meta keywords based on the author's concepts of the page, can provide useful insights into page content.

Keywords are extracted from the contents of the page using a combination of information retrieval techniques and natural language processing. They indicate the use of words on a page and usually number between eight and twelve. This is a quick to listen to list which can enable a quick rapid about whether a
page is useful. Keyword extraction simulates visual scanning through word spotting.

**How BrookesTalk supports modelling the information on the Web page**

When the blind or visually impaired user finds the page which they think contains the information they require they need to find exactly where the information is on the page. BrookesTalk provides a scanning action in the form of an abstract which is a collection of significant sentences drawn from the page. Using a combination of information retrieval techniques and natural language processing, we have extracted the key trigrams (phrases consisting of three words) from the contents of the page. We then put them back into the sentences in which they were found and present the collection of sentences as the abstract of the page.

Abstracts usually contain about 25% of the number of words of the whole page. This cuts down considerably the reading time of the page using synthesised speech. The abstract consists of a set of disjoint sentences. The semantics of the sentences are preserved, unlike keywords, and the listener can make a good guess as to the content of the text left out between the sentences. In this way users can find where the required information lies on the page to be read out in detail later. Keywords and abstracted sentences represent the words and sentences picked out when a sighted user scans a Web page trying to make sense of it.

**How do we know that BrookesTalk is providing the best summarisation?**

The development of the summarisation algorithms for BrookesTalk is part of a PhD project. The extracted keywords and abstracted text have been tested for representing the 'content' of a page. Over thirty subjects were used to factor out individual differences in their concept of the content of the page. Concepts concerning 'content of a page' are complex and philosophical. We view our summarisation as a best fit given the
parameters we included in the algorithm. We feel justified in using this approach since however successful or unsuccessful the summarisation process is, there is just not enough time for blind visually impaired users to read everything on every Web page. Also when sighted users scan a page they could make a wrong decision about its content. The PhD work continues. New techniques are being developed and new parameters included. We hope soon to be able to distinguish a change of topic within a Web page. If different topics can be identified in a page we can provide better summarisation for each individual topic and avoid the confusion inherent in assuming the content of the page concerns only one concept. The results of new research work will be in used in further versions of BrookesTalk.

Conclusion
At the Speech Project we view the Web as a structure that contains information, and HTML code as a vehicle for conveying information, rather than as a set of formatting instructions. Standard GUI browsers translate HTML files into images and formatted text which conveys the underlying information in a visual medium. BrookesTalk translates the HTML file into structures that convey the information in an aural medium. We will continue to look for ways to get behind the visual nature of the World Wide Web and analyse what is really there so that we can structure the information for useful presentation using speech.

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