

# Improving Web Accessibility Using Content-Aware Plug-ins

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## ABSTRACT

This paper describes a novel approach to improve blind and visually impaired people's access to the Web by using a content-aware Web browser plug-in coupled with audio and haptic tools. The Web plug-in accesses the current mouse position on-screen, and makes the co-ordinates available to the audio and haptic modalities. This allows the user to be informed when they are in the vicinity of an image or hyperlink; previously they would only have been informed when they are physically on the link. Thus, when the user is close to an image or hyperlink, haptics and audio will be used to inform and guide them to the actual spatial position. The Web browser plug-in and the associated audio and haptic feedback tools are described in the paper. Finally, results from a pilot study on the usability of this system are also presented.

## Categories & Subject Descriptors :

H.5.2 User Interfaces: auditory feedback & haptic I/O;  
H.5.4 Hypertext/Hypermedia: navigation

**General Terms:** Design, Human Factors.

**Keywords:** Assistive technology, Web plug-in, accessibility, navigation, auditory & haptic interfaces.

## INTRODUCTION

The Internet has changed people's way of life because of the vast amount of online information and services. However, blind and visually impaired people do not benefit fully from this due to the limitations of current assistive technologies and poor accessibility of the Web. A recent survey conducted by the Disability Right Commission reports that only 19% of 1000 tested UK Websites' homepage pass the priority 1 check specified in the W3C's Web Content Accessibility Guidelines [14]. This means that people with disability, especially visual impairments, will have problems in accessing information on most of the websites using the currently available assistive tools, such as screen readers and Braille displays. Besides the limitations in handling graphs and animations on a busy Web page, these tools also impose restrictions on the way that blind people browse the Web, which is in a linear and time-consuming fashion. Therefore, a new tool that addresses the above mentioned problems is needed.

WebSpeak [6] and BrookesTalk [17] have been developed to output text-to-speech, providing an overview of web content for the user. A study by Donker et al. [4] has examined the development of auditory interaction realms to represent the layout of web pages and to support navigation. It has been demonstrated that embedding sounds in an environment improves location awareness of objects. Roth et al. [12] have investigated adding the haptic modality to an auditory environment. In this study, sounds represent the nature of the HTML tag touched.

Research has shown extracting semantic information and reformatting pages, can promote levels of accessibility. SWAP has been designed by Seeman [13], to enable users to orientate themselves on a page, scan and access the sections that interest them the most. Harper et al. [7] have developed middleware to dynamically annotate web pages with additional context information and previews of hyperlinks.

A system has been developed by Caffrey and McCrindle [2] which utilises haptic feedback and speech recognition to aid browsing. However the range of haptic primitives employed in the system is limited. By making use of the gravity well effect the user may not gain complete spatial awareness of the whole shape of the object being navigated to. The role of speech recognition in the system was found to be useful, though restricted by machine constraints and errors due to misrecognitions.

A content-aware Web browser plug-in, which allows users to actively navigate on a Web page using a combination of audio and haptic tools has been developed. The main purpose of this approach is to give users an opportunity to explore a Web page's layout through active haptic interaction. A force feedback mouse is used and its cursor position is constantly monitored by the plug-in which detects the surrounding objects. If the plug-in finds an object nearby then it will inform the user by enabling the haptic and audio features. Depending on the user's intention and the context of the task, appropriate prompts can be given, such as giving users guidance to the desired destination or informing users about nearby objects.

The described approach presents a new way of human computer interaction which benefits visually impaired and blind people by increasing their level of spatial awareness as well as making the Internet more accessible. Using a force feedback mouse to access Web pages is a new experience to blind people in particular. The advantages of being able to explore Web pages interactively will

hopefully outweigh the amount of time that blind people need to be familiar with the new technology. Suitable training to shorten such learning processes is planned for future work.

### BROWSER PLUG-IN

The two main browsers currently available for the development of plug-ins are Microsoft Internet Explorer 6.0 [9] and Mozilla Firefox 1.0 [10]. Internet Explorer and Firefox both offer distinct advantages and disadvantages. IE currently has over 90% of the market share for Internet browsers, resulting in any plug-ins developed being widely compatible. However, Firefox has 7.4% of the market share, and this is increasing [11]. Firefox is a Web browser which is based on Mozilla and makes use of the Gecko layout engine. This offers advantages for developing extensions including cross platform compatibility and accessibility of source code. Mozilla also fully implements the W3C standards [16].

### Overview of Extension Architecture

Mozilla extensions use a range of programming languages and interfaces. Javascript is the primary scripting language, and is used in conjunction with Cascading Style Sheets (CSS) and the Document Object Model (DOM) [3] to access and manipulate HTML elements in real time.

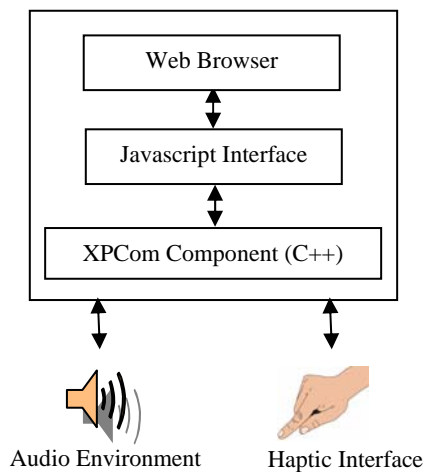


Figure 1. System Architecture.

The Javascript API can be extended by writing a Cross Platform Object Module (XPCOM). XPCOM is a framework which allows large software projects to be broken up into smaller, manageable components. To achieve this, XPCOM separates the implementation of a component from the interface, which is specified via the Interface Definition Language (IDL). XPCOM is structurally similar to Microsoft COM, however it is designed to be used mainly at the application level [15]. XPConnect provides a bridge between the component and the Javascript external, allowing constructors and methods

from the component to be accessed via Javascript. An overview of the architecture is illustrated in Figure 1.

This architecture enables the rapid development and prototyping of extensions for the Firefox browser.

### Plug-in Development

There are four main requirements for the development of the plug-in:

1. The current position of the mouse cursor should be captured
2. The position of each HTML element on the screen should be obtained
3. If the mouse cursor is within a distance, DIST, of an HTML element, the relative co-ordinates of the mouse pointer should be calculated.
4. These relative coordinates should be passed to an external application. In this case the applications are a real time audio simulation environment and a haptic device.

The first three requirements were fulfilled by the creation of an external that was written in Javascript:

1. The current position of the mouse pointer was obtained by adding a mousemove listener to the browser window. The mouse position was updated each time the user moved the mouse via event.clientX and event.clientY methods.
2. The position of each HTML element was accessed by parsing the Document Object Model via Javascript, and obtaining the co-ordinates via the stylesheet properties for each element - element.offsetTop and element.offsetRight.
3. The element was divided into nine sections, where each section has a particular coordinate range. Figure 2 illustrates how the element was divided up, and the range of coordinates that are associated with each section. It was necessary to take the height and the width of the element into consideration, for images this was calculated using the elements stylesheet properties. The height and width of a hyperlink was calculated by taking into account the number of characters contained in the hyperlink, and the size of font used. The x and y values are the respective horizontal and vertical distances from the nearest image edge. Note that  $\{x, y\} < DIST$ .
4. The final requirement was fulfilled via the creation of an XPCOM component, which was developed in C++. This component provides methods for sending control messages from the browser to the audio simulation environment via UDP. The format of the messages sent is  $x1:y1, x2:y2, \dots, xn:yn$ , where n is the number of objects in the vicinity of the mouse cursor. This

message is then parsed by the audio simulation application.

$(x, y)$	$(0, y)$	$(-x, y)$
$(x, 0)$	$(0, 0)$	$(-x, 0)$
$(x, -y)$	$(0, -y)$	$(-x, -y)$

Figure 2. Object Coordinates.

It was also necessary to interface the browser with the haptic device. This was realized via the installation of a plug-in provided by the haptic device manufacturer, which was then accessed by the extension via Javascript.

### HAPTICS

The Logitech Wingman force-feedback mouse has been chosen to facilitate on-screen navigation, due to its compact size and compatibility with the Firefox browser. The Immersion Web plug-in has been linked to the content-aware Web plug-in. Supporting software can model a small array of haptic effects including stiffness, damping, and various textures, which can then be called through the Javascript. This has facilitated the exploration of objects with additional force-feedback.

The following haptic primitives have been employed; the 'enclosure effect' has been coupled with clipping effects bordering the image. This has given the illusion of a ridge, which needs to be mounted. Cursor clipping motion increases a user's psychological perception of the wall's stiffness [8]. Upon rolling over the image, a 'buzz effect' has been produced along with force-feedback. The dual effect of audio coupled with force-feedback, will heighten the sense of awareness that the user is directly on the image. To provide location awareness of the cursor when directly hovering over a hyperlink, the 'periodic effect' has been used. This effect produces a wave that varies over time, promoting a locked sensation, when directly hovering over the link. It is intended that this will promote a sense of orientation within a page for the visually-impaired user.

### REAL-TIME AUDIO

The audio feedback for this system gives the user a sense of navigation in relation to an image or a link on the page. The audio is designed and played back in Max/MSP, a real-time audio programming environment. Netsend, an MSP external object is used to receive x and y location coordinates sent via UDP from the Web plug-in. As the user rolls over an image or a link with the force-feedback

mouse, a sound is played to reinforce the haptic response. These sounds can be classified as auditory icons defined by Gaver [5] as sounds sampled from real world environments based on the attributes of source events such as size, material, and force. For this system the image sound icon is a short descriptive auditory clip of a camera shutter clicking, suggesting a photograph or image. The auditory icon used to depict a link is a short "metallic clinking" sound suggesting the sound of one link in a chain hitting off another.

Outside the image or link space the cursor location is mapped to panning and pitch-shift parameters of a continuous background sound. The x-value co-ordinates are mapped to a panning patch in Max/MSP so that as the user moves the cursor along the x-axis the audio is panned to that position. Similarly the pitch varies according to the position on the y-axis; as the user moves the cursor upwards, the background sound is pitch-shifted upwards to represent this movement. This background location sound is based on musical parameters rather than a real world sound source and is therefore classified as an earcon [1].

### USER EVALUATION

Initial user testing has revealed that the addition of non-visual cues has enabled users to locate images and links more effectively on a Web page.

Three blindfolded users were given information-seeking tasks on different Web pages. Two computer test environments were employed; one having a browser and JAWS screen-reader and the second with screen-reader, browser and content-aware plug-in. The think-aloud protocol was employed to render rich qualitative feedback. Each user was asked to describe their location in terms of the spatial layout of links and images. The users were then asked to subjectively rate the quality of audio and haptic cues.

Results showed that the panning audio location cue was difficult to perceive with the screen-reader. The pitch-shifting earcon was more easily perceived and the short auditory icons were effective in conveying object information. Generally users were overloaded in the auditory channel due to the amount of cues that had to be simultaneously processed. In terms of haptics, the findings showed that the users were able to locate images quickly due to the force-feedback effects that encased the graphic and benefited from additional awareness when hovering over a hyperlink. The haptic effects were found to complement the audio cues created.

### FUTURE WORK

The content aware Web plug-in will be extended to include more features to assist visually impaired Internet users. The system will be developed with a view to reducing cognitive workload associated with the need to remember structural and contextual information for Web pages. The current

functions of the plug-in will be extended and improved in order to achieve this.

The content-aware system will be adapted so that it will function with other browsers. The type of information that can be sent to haptic and audio environments will be enhanced to allow improved feedback to convey more complex information. A component will be designed that will summarise and interpret sections of a web page.

In order to overcome the problem of screen-readers outputting extraneous information from a web page, a haptic feature will be developed to automatically direct users to certain sections of the content. The path taken through a page could be customised by the user, allowing time to be saved by skipping over information that is not useful to the individual.

One of the most important considerations in designing audio for a non-visual interface is that the auditory space overloads much faster than the visual space. Initial user testing has highlighted the fact that too many sounds presented simultaneously will confuse the user. Short auditory clips are preferable to convey simple information quickly. Continuous sounds should be used sparingly and a hierarchy of significance of each sound should be determined before it is used.

The audio and haptic interface designed for this plug-in is an example of the ways that multi-modality can be used to enhance a visually impaired user's awareness of navigational position and location of objects on a page. Following an extensive survey and analysis of the current problems that visually impaired people experience when interacting with the Internet, a more comprehensive system will be developed.

## CONCLUSION

This paper has described a novel technique which can determine when a user's cursor is in close proximity to a region of interest on a Web page, e.g., a hyperlink or image. By rendering the spatial visual information using multi-modal interfaces, users are not only informed of these regions of interest, but are also guided to them using audio and haptics. This technique also promotes the use of novel interactive devices to increase spatial awareness, allowing users to construct a mental spatial map of a Web page.

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