Developing An Assistive Haptic Framework For Improving Non-Visual Access To The Web

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Abstract

With the growing focus on user-centered design by HCI researchers and practitioners, it is perhaps ironic that the visually impaired community continues to encounter challenges when interacting with the Web. Access is believed to be improved through the use of haptic technologies. However, due to the limited availability of targeted haptic design guidelines, developers could arbitrarily select and map sensations, with little consideration given as to how the sense of touch could provide assistance to a blind user. Research aims to address the limitations associated with existing assistive technologies, by developing haptic feedback which provides both spatial and navigational assistance when accessing the Internet. This research aims to culminate in a haptic framework, for designers to reference when developing accessible solutions for the Web.

Background

The Internet offers considerable potential to the visually impaired community. However, recent evidence suggests that needs of blind and partially sighted web users are often overlooked [6]. Barriers to access are attributed to the graphically-oriented presentation of information on a page, coupled with limitations imposed by assistive devices. The process of navigating through a busy page is known to be tedious, largely due to the linear output of screen reading technologies [8]. Gaining an overview of the spatial layout of page elements can also pose a challenge. Improved non-visual presentation of information and additional navigational cues would not only assist visually impaired users when exploring unfamiliar web pages, but would also help when targeting particular sections of each page. Considerable benefit would be gained by those users who collaborate on web-based tasks with sighted peers, as discussed in further detail by Mynatt & Weber [4].

In contrast with other modalities, the haptic channel presents the advantage of bi-directional information transfer between the user and the virtual environment, and when utilised, is known to reduce the burden on vision and audition, freeing these senses for other tasks [5]. O'Modhrain & Gillespie [5] have stated that in certain instances, it is possible to substitute haptics for other sensory modalities, such as graphical user interface (GUI) exploration for visually impaired individuals. As haptic technologies develop and devices reduce in cost, using the sense of touch becomes a more viable method for creating a universally accessible solution to browsing the Web. However, existing web accessibility guidelines do not extend to the use of haptic feedback. Similarly, haptic

design guidelines do not provide the focused assistance needed for use on the Web. Limited haptic interface design guidance may encourage designers to select arbitrary sensations to represent elements on a web page, rather than develop stimuli which provide assistive benefit to the user. Choice may be influenced from the limited range of effects currently offered by haptic technologies. Poorly designed or inappropriate sensations may reduce the quality of the subjective experience. Lack of design conventions could lead to the reuse of the same haptic sensation to represent multiple page elements, which could result in confusion for the visually impaired user. Mappings could also vary from site-to-site, meaning that the user would need to invest time and effort explicitly learning the meaning associated with each sensation. A haptic framework housing a library of assistive feedback would allow designers to select and replicate standardized sensations, which would provide assistance to a visually impaired user when exploring a web page. Accompanying recommendations would aim to discuss the application of assistive haptic icons within the context of a page.

Design challenges

The main design challenge would be translating an interactive, spatially presented, visually dense interface, into an efficient, intuitive and non-intrusive non-visual interface [4]. A direct graphical-to-haptic conversion would not provide benefit to users who have never experienced sight in earlier life. Haptic feedback would need to be specifically designed to assist the exploration and targeting processes. Assistive cues should not only enable visually impaired users to browse pages independently, but should also allow blind and sighted parties to work together to reach a common goal. To support joint operation, the respective presentations of both visually and non-visually-orientated technologies should be synchronized [4]. This could be achieved by providing visually impaired users with an assistive haptic layer for use with current browsing technologies (e.g. Internet Explorer or Firefox).

In order to develop an assistive haptic layer, research would need to assess the information that needs to be perceived by the user to provide assistance, determine how to represent this through the use of haptic technologies, and investigate how these haptic sensations can be perceived effectively by the user. Developing assistive feedback that communicates an underlying sense of meaning to the user would offer considerable advantage.

Related work

Haptic technologies have been used to promote spatial awareness within a virtual environment. Mynatt & Weber [4] refer to the development of the GUIB system, whose design allowed visual information to be transformed into a tactile representation based on the spatial representation of a GUI. Icons, buttons, controls and menus on the desktop have been tactually perceived using the Betacom Screen Rover [1] and the Moose [5]. However, it is thought that haptic-based solutions have yet to target the issues pertaining to communicating the semantic content associated with HTML markup, presented on a web interface.

In order to assist navigation, Yu and Brewster [7] have enabled visually impaired users to haptically follow the grooved lines in graphs, to promote awareness of the trends in

complex numerical datasets. Following a groove is thought to reduce time spent locating reference points, minimizing confusion within a virtual environment. Non-visual feedback has been found by Jacko et al. [2] to assist with complex mouse-based tasks, such as the 'dragging and dropping' of files on an interface. The users were able experience a haptic sensation upon the correct positioning of the file using the Logitech Wingman force-feedback mouse.

With regards to haptic interface design, MacLean [3] has discussed the use of a "top-down approach", allowing the designer to consider the need for providing a non-visual interface, and finding a solution from a suite of technologies and methods. The developer should ideally have knowledge of tools and affordances, when designing feedback. However, this is not always the case. An assistive framework would benefit both experienced and non-experienced developers, allowing them to adhere to a standardized set of mappings.

Research goals & contribution

- To design and refine assistive haptic feedback to inform positional awareness and to provide navigational feedback when exploring a web page. The aim is to develop haptic sensations which improve understanding of the information presented and heighten levels of subjective experience.
- To develop targeted haptic feedback for visually impaired web users to assist them when working on collaborative tasks in conjunction with their sighted colleagues. The aim is to synchronize the presentation of both non-visual and visual-oriented browsing technologies.
- Establish an assistive vocabulary, with accompanying recommendations covering issues of haptic salience, aesthetics, device and perceptual constraints. The framework aims to contribute to the limited body of knowledge on haptic interface design for the Web, and provide a valuable reference tool to support developers in both the design and evaluation processes.

Methodology

An exploratory approach is required to develop assistive sensations, due to the limited level of research in haptic interface design for an essentially two-dimensional interface. Scenario-based techniques are utilized as a tool for inspiring and evaluating design ideas for assistive feedback. The scenarios themselves are based upon the observation and task analysis of visually impaired screen-reader users accessing the Web. This process is thought to identify interactions made during the exploration and collaboration process, which could be improved through the use of assistive haptic feedback.

The scenarios are presented within the context of an assistive web interface, allowing small design teams to consider the unique qualities offered by touch [3], and how these can be used to inform design. Affordances and metaphors appropriate to the haptic domain will be considered, to produce sensations which convey an underlying sense of meaning to the user. A participatory approach is applied to acquire the perspectives from visually impaired screen reader users and haptic interface designers, both of whom are thought to be vital in the process of targeted assistive haptic feedback design. The method enables teams to consider how haptic sensations can work in conjunction with

other haptic stimuli suggested for use on a page. Interacting with an input device other than a keyboard is often a new experience for a screen reader user, so design should also consider the additional support required when using a mouse. Prototypes can be refined to a sufficient standard through follow-up sessions, where designs are evaluated against the same scenario, and against additional scenarios exploring other contexts of use (e.g. when gaining general or in-depth knowledge from a page).

Current status & open issues

One comparison study profiling the use of a screen reader against using assistive force-feedback has been conducted [8]. Scenario-based design techniques have been used to develop targeted assistive feedback for the purposes of assisting a visually impaired user to perform a web search. Three iterations of design have been completed, with a fourth in progress. Lower-fidelity prototypes of commonly occurring page elements have been strengthened and implemented dynamically on web pages using the content-aware plug-in discussed by Yu et al. [8]. Findings from the research will form the basis of the assistive vocabulary. The next logical step would be to design sensations which support visually impaired users when collaborating on web-based tasks with sighted users. A method for evaluating the resulting feedback would also need to be formulated.

References

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