Physical Usability and the Mobile Web

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ABSTRACT

This paper examines the degree of overlap between good design for physical ease of access on the Web in general, and design for physical ease of use on the mobile Web. There are marked differences in the basic interaction techniques used and usability issues experienced. As a group, people with physical impairments tend to have a broader range of needs. These differences impact Web page design in various ways. Problems can be addressed in a unified way by designing for device independence. At least for physical ease of access, a unified set of mobile/accessibility best practice guidelines would be mutually beneficial. This approach may be helpful in preventing fragmentation of the Web.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *input devices and strategies, interaction styles*

General Terms

Design, Human Factors.

Keywords

Mobile web, accessibility, usability, text entry, selection, navigation, physical disability, input devices, Web browsing, WCAG, UAAG.

1. INTRODUCTION

The challenges of designing for the mobile Web are strikingly similar to those of designing for accessibility. On the face of it, the mobile device's small screen, different operating modalities and low communication bandwidth seem to mirror the access requirements of people with sensory, physical and cognitive impairments.

This paper focuses specifically on physical usability. It asks: How similar are physical usability issues for desktop users with physical impairments and for mobile users, when accessing the Web? Are similar solutions appropriate?

In the physical domain, accessibility issues are rarely clear cut or easily quantifiable. Keystroke navigation is a notable exception – if it is not provided, then people are excluded. Users with physical disabilities have very different input methods, but once they have a method that is best for them, usability issues center around the time and effort required to perform a physical task, and the accuracy with which it can be done. Making a task physically easier for existing users will also bring it within the capabilities of others who were previously excluded. So much depends on the individual's patience and perseverance that it is impossible to say whether a given user with a given device, on a given day, will complete a Web based task successfully. As a result, this paper focuses on issues that make Web pages more or less *usable*, rather than accessible or not accessible.

First, this paper gives a brief overview of interaction techniques, issues, guidelines and solutions developed in the domain of physical Web usability (with the assumption of a desktop environment). Interaction techniques, issues, guidelines and solutions for mobile Web access are then presented and the two domains are compared.

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2. PHYSICAL USABILITY

2.1 Interaction Techniques

Although the vast majority of desktop users provide input via a standard keyboard and mouse, there is an enormous range of other options available to people who find one or both of these devices difficult to use [7]. These options include alternative keyboards and pointing devices, speech input, keyboard-based pointing methods, and pointing-based typing methods (e.g. use of eye gaze tracking with an on-screen keyboard and selection by dwelling on an item). Users with very limited motion can use one or two binary signals generated by a physical switch, tongue switch, EMG sensor or other device, and can control a computer by scanning through the available options (manually or automatically) and selecting the items of interest.

Because all of these input techniques can provide text input, the standard way to accommodate this diversity is to ensure that browsers and Web sites can be accessed and controlled via keystrokes. However, providing keyboard navigation does not solve all physical usability problems.

2.2 Issues

One significant issue is speed of input. For switch users, typing rates may be just a few words per minute. Selecting on-screen items by dwelling on them typically adds up to 3 seconds to the time required for each selection. Some disabling conditions, such as Parkinson's Disease, cause slowness of movement, so that typing rates on a physical keyboard can also be greatly reduced.

Accuracy is another major issue. People with motor impairments may have high error rates when using keyboards and mice [14], but often need or prefer to use these standard devices. Common errors include unwanted extra characters, and unintentional or wrongly positioned mouse clicks. Alternative input mechanisms such as speech, eye gaze pointing or EMG can also be inherently error prone or difficult to control. People with severe motor impairments are often pioneers in the use of such technologies, at a stage when they are not robust or reliable enough to become more generally popular.

These broad issues give rise to some specific challenges when using the Web. Sites that give users a limited time to fill in and submit a form may be unusable. Some sites even present moving targets! Target size is an important consideration – the larger it is, the easier it will be to select. Typing passwords accurately can be a challenge, so sites that lock users out of their accounts after a number of failed login attempts also pose barriers.

It is also crucial that users are able to find information within a Web site as easily as possible. If it takes sixty seconds of hard work to select a link or scroll down the page, users need to know that they are navigating in the right direction. One major study of Web accessibility found that the two main usability problems reported by people with motor impairments were lack of clarity in site navigation mechanisms, and confusing page layout [4]. The third most commonly reported problem was small text and graphics, which would be difficult to select.

2.3 Solutions and Guidelines

Physical usability issues are significant even when the user has chosen the most accessible input mechanism available. Usability can be improved with support provided by the operating system, the browser, transcoding software, or by Web sites themselves.

Operating systems provide useful solutions such as the ability to control the delay before a key starts to repeat when held down. Assistive software such as word prediction can improve the user's input rate and accuracy. Although there has been much research into mechanisms for making pointing and clicking easier [5,15], there is little operating system or browser support currently available. In particular, users cannot ask to have all targets increased in the way that text size can be increased. Desktop browsers render check boxes and radio buttons at a fixed, small size.

Desktop browsers do provide other physical usability supports, including the ability to increase the size of menus and scrollbars. The W3C's User Agent Accessibility Guidelines (UAAG) [8] provide recommendations including

- design for device independence (e.g. allow keystroke-based navigation, which can be generated by many different assistive technologies);
- ensuring user access to all content (e.g. automatically pause a time-sensitive presentation to allow user input);
- and provision of direct and sequential navigation mechanisms (keyboard shortcuts and tabbing through controls).

Mankoff et al [11] experimented with a Web browser specifically designed to support Web access by users interacting via four keys or switches. It had an explicit control area for accessing browser functions and the links on the current Web page. This provided efficient navigation. It also showed an image preview of the link with focus, helping users to decide whether to follow that link.

Users are often unaware of browser and operating system features that may be helpful [4]. An alternative approach is to transcode individual pages before they are presented to users. Mankoff et al [11] identified several useful transcoding techniques for supporting low bandwidth input, including the addition of links to support backwards and forwards navigation at each paragraph break, other links for skipping unwanted sections, information about link targets, and specialized form widgets with built-in scanning capabilities. IBM's Web Adaptation Technology [6], a client-side transformation system, includes Web page transformations that could improve physical usability such as changing the text size to make links bigger and linearization of pages to reduce horizontal scrolling. It also provides easy access to little known operating system features such as the Mouse Keys feature for keyboard-based pointing.

The W3C's Web Content Accessibility Guidelines (WCAG) also cover physical usability. Relevant guidelines from the WCAG 1.0 recommendation [2] include

- providing a logical order for tabbing through page links;
- making event handlers device-independent (e.g. avoid actions that can only be triggered by a mouseover event, since some users will not have a pointing device);
- ensuring that users can control time-sensitive content changes (e.g. change the length of time allowed for filling in a form);
- using link text that is meaningful when taken out of context in a list of page links;
- providing shortcut keys to access important features;
- and providing navigation bars.

WCAG 2.0 [1] is a W3C working draft. It makes similar provisions. The guidelines focus on input device independence, and the ability to do keyboard navigation. The WCAG and UAAG guidelines do not address the significant problems of users with motor impairments who are using direct selection to select small non-text objects.

3. MOBILE USABILITY

3.1 Interaction Techniques

Interaction techniques for mobile users are also very varied. There are many different text entry mechanisms based on the phone keypad and novel input devices [10]. Some people use a stylus to make selections or gestures on a small screen. Some use speech commands. The most striking difference between mobile input mechanisms and those used by people with disabilities is that the very limited bandwidth input mechanisms are not represented.

Today's typical mobile device is relatively limited. It may have no means for direct selection, relying on key-based navigation and keypad text entry. Future devices using different forms of display (e.g. head mounted projections onto eyeglasses) may take a very different approach, replacing the use of keys with direct selection, gestures, EMG input and/or greater use of speech.

3.2 Issues

Input speed and accuracy are both impacted in the mobile context. Keypad-based text entry mechanisms are slower than those for a full keyboard. Key based navigation takes longer than direct selection. It may also take longer (or be impossible) to follow a link, because of reduced communication bandwidth and limited memory and processing power on the mobile device itself. Many users are unaware of, or do not have, the ability to go back from a link they have followed [12]. This increases the cost of selecting a link in a similar way to the cost experienced by desktop users with motor impairments.

It seems likely that working in a mobile environment, especially on moving vehicles, will introduce errors in typing and navigation, but little has been published in this area. Techniques for error rate measurement appropriate for mobile devices are emerging [13] but have yet to be widely applied. Speech and gesture input mechanisms may be especially error prone in mobile environments with background noise and movement.

These general issues give rise to specific challenges when using the Web that echo *some* of those experienced by people with motor impairments. Sites that give users a limited time to fill in and submit a form may be unusable. Scrolling around a large page on a small screen is tedious and disorientating.

Other features of the mobile environment also generate issues that are similar to physical usability issues. The cost (in time and money and the difficulty of going back) of downloading pages to mobile devices makes it crucial that users are able to find information within a Web site as easily as possible, with a minimum of 'dead ends'. Since many devices provide key-based navigation only, efficiency of key-based access becomes important.

3.3 Solutions and Guidelines

The W3C's Mobile Web Initiative aims to make Web browsing from mobile devices a reality. It has drafted a set of guidelines for Web pages intended for mobile access [12]. These guidelines are in fact derived from the WCAG guidelines, and extend them by adding considerations that are specific to the mobile environment. The guidelines most relevant to input are:

- Keep the number of keystrokes to a minimum.
- Avoid free text entry where possible.
- Provide pre-selected default values where possible. (e.g. pre-fill a form field labeled 'email' with the user's preferred email address when this is known)
- Specify a default text entry mode, language and/or input format, if the target device is known to support it.
- Create a logical tab order through links, form controls and objects.
- Use navigation mechanisms in a consistent manner (with the suggestion of using a "drill down" method and means to skip entire sections of content)
- Assign access keys to links in navigational menus and frequently accessed functionality

Mobile Web pages are recommended to conform to both the WCAG and Mobile Web guidelines.

While text input rate does remain an issue in the mobile environment, techniques developed to support people with low bandwidth input are already proving useful (e.g. word prediction, reduced key typing with automatic disambiguation).

Researchers have also investigated the potential of transcoding technologies to dynamically adapt Web pages for serving on mobile devices [9]. Although transformations focus on page reformatting to fit small screen devices, those providing a compact efficient navigation structure also make physical access easier. For example, consider a keyboard user looking for information on Collie dogs on a pet shop web page. She can get there in far fewer keystrokes if the navigation structure allows her to jump straight to the section on dogs without having to tab through every kind of cat along the way.

In addition, pages that are able to scale down to a small display screen with small elements will also be capable of adapting to a large display screen with large elements that are easy to select. This is an example of a transformation that is intended to support visual display but may also benefit physical usability.

4. COMPARISON

There are strong similarities between physical usability issues in mobile and accessible desktop Web browsing scenarios:

- They share the need to support a great variety of different input devices and interaction techniques. Both require Web pages that make no assumptions about the input mechanisms that will be used, and that support efficient key-based navigation and selection.
- Both communities also benefit from pages that are flexibly authored so that the layout can be adjusted, for example to fit a small screen, larger text size, or to minimize scrolling.
- Text input may be slower and more error prone than is normally assumed for a desktop environment, so user control of timeouts, techniques that reduce the amount of typing required, and opportunities to correct errors are all useful. For example, pre-filling form fields with previously used entries will benefit both communities.
- Navigation is likely to be slower, and the cost of following wrong links is high. Pages that provide clear and efficient navigation mechanisms with the ability to skip sections will benefit both communities.

However, physical usability in a mobile environment is *not* just a rehash of desktop physical usability issues. There are some significant differences:

- The very low bandwidth physical input mechanisms used by people with disabilities are not appropriate for mobile users, who already have higher bandwidth mechanisms available. For example the use of gestures made with a pen allows text input at rates far higher than scanning an on-screen keyboard. In the future, the mobile community may be less concerned about reducing the amount of typed input, because more efficient text entry mechanisms will be available, while it will remain an issue for people with severe physical impairments.
- The basic assumptions about mobile text input are very different to those of physical usability on a desktop. In the mobile scenario, typing is generally slow but little is known about error rates. The slower desktop typists are much slower than mobile users, and error rates can be very high. Three attempts to enter a password may be sufficient for mobile users, but not for desktop users with typing difficulties.
- Difficulty with direct selection is a major issue in physical usability, while direct selection is not often used on today's mobile devices. Where it is used, a high level of precision can be assumed. Users with physical impairments are more heterogeneous. Whether using key-based or direct selection, long selection times

and high error rates must be accommodated. Techniques used by people with disabilities to make it easier to point to targets may also be helpful to people with no impairments when pointing to very small targets. So developers of devices with small, high resolution screens and direct selection facilities may find techniques of interest in the accessibility field.

In general, where similar needs are identified, physical usability issues represent a broader range of requirements. Enhancements to physical usability will often benefit mobile users.

Designers building pages specifically for mobile delivery may be tempted to use techniques that actually introduce accessibility problems in other contexts. For example, it might be useful for mobile Web pages to use small images for links that are to be displayed on a small screen, but extra large links are preferable to make desktop access physically easier. A more appropriate general requirement would be to allow target size to be adjusted depending on the delivery context. Future browsers that support such scaling would then adjust target sizes to suit the current user and device capabilities.

Many of the requirements of the two communities lead to very similar general Web page design guidelines, the overriding principles being to avoid making assumptions about input mechanisms, to support a variety of navigation mechanisms, and to support users in providing input wherever possible. Combining the W3C WCAG and current Mobile Web best practice guidelines will actually enhance physical accessibility for all users, not just those in mobile contexts.

5. CONCLUSIONS

This paper set out to explore the similarity between physical usability issues for desktop users with physical impairments and for mobile users, when accessing the Web.

The physical interaction techniques used by the two groups are very different, but often give rise to similar input rate and accuracy issues. Some text entry techniques pioneered by people with disabilities have already been adopted for mobile access, and this trend is likely to continue in the future.

However, it would be wrong to conclude that the issues are basically the same, and that the same solutions are always appropriate in both domains. People with physical impairments tend to have a more extreme range of needs and requirements. Extremely low bandwidth input using a single switch and scanning, for example, produces typing that is much slower than that of mobile text entry mechanisms. People with mild to moderate motor impairments rely heavily on direct selection, which is not currently common for mobile Web users.

These differences do impact Web page design. Designs that are highly optimized for the mobile context will be less physically usable where the needs of the two communities pull in opposite directions. Guidelines and approaches that emphasize flexibility typically benefit both communities.

It seems feasible that these two communities could develop a single set of mutually beneficial guidelines and techniques for maximizing physical usability. This may encourage designers to produce pages that can be used in multiple delivery contexts. If this happened, users with physical disabilities would find the Mobile Web a welcoming place.

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