Wristband On: An Exploratory Study of Wearable Input for People with Visual Impairments

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ABSTRACT

Users with visual impairments face challenges when interacting with the increasingly ubiquitous touchscreens of mobile devices. As an alternative, wearable technology has the potential to provide unobtrusive input that can facilitate effective non-visual interaction. In this preliminary work, we explore the intersection of wearable technology and accessibility with a wristband prototype for controlling an iPad, and a planned interview study. At the time of the writing, we have completed one interview. We hope the eventual results of the study will inform and motivate the design of future accessible wearable technology.

Author Keywords

Wearable technology and devices; accessibility; mobile devices; exploratory study.

INTRODUCTION

Google Glass marks a new epoch of wearable technology. Previously, wearables were the domain of electronic hobbyists and haute-couture fashion designers, who incorporated LEDs into skirts or motion detectors into badges [10]. Now, with the rising popularity of health-information trackers, such as Nike's FuelBand or the FitBit Flex, that interface with users' mobile phones, the practical uses of wearable devices are catching on with the general public. Wearable technology also has potential to be powerful accessibility technological devices, especially used with existing mobile devices.

Figure 1: Our study materials included our wristband prototype, a Bluetooth modem, an Arduino board, and an iPad.

The apps and tools available on smart phones and tablets make mobile devices more popular than ever. Apps like barcode readers, color identifiers, and even crowdsourcing technology like VizWiz [1] allow users with visual and physical impairments to complete everyday tasks independently. However, most mainstream mobile devices are touchscreen based and rely on gestures for user input. Unfortunately, touchscreens are not optimally designed for users with visual impairments. These devices are generally devoid of tactile landmarks, making it difficult to non-visually learn and perform gestures accurately. Projects like Slide Rule [3] and accessibility features like VoiceOver [11] provide alternative sets of gestures for people with visual impairments, but even with these technologies, direct interactions may be socially disruptive and inconvenient for quick interactions, such as checking the time or dismissing a call. Wearable devices may help protect users' privacy by allowing them to discreetly and remotely interact with their phone. Furthermore, they can eliminate the need to physically retrieve the device for certain interactions, which might even make interacting with a device in public safer and more secure for users. In addition, wearables can be made to be as unobtrusive as possible, or even stylish, which may alleviate some of the social stigma of using accessibility technology.

To explore the potential benefits and challenges of wearable input as an alternative means of mobile interaction for people with visual impairments, we created a wearable device in the form of a wristband that interfaces with an iPad and uses iOS's built-in screen reader, VoiceOver. We then planned an interview study that incorporates interaction with the wristband and asks participants about their current mobile device use and the potential implications of wearable input. We are particularly interested in how wearable interaction will impact privacy, a personal sense of security, and efficiency of interaction for people with visual impairments.

At the time of writing, we have conducted an interview with one participant. We hope that the eventual, completed results of this work will shape future research on wearable technology and accessibility by outlining social and practical issues of wearable technology to investigate further.

RELATED WORK

Our study draws on work in wearable input, the social implications of currently existing accessibility technologies, and mobile interaction for users with visual impairments.

Wearable and On-body Input

A number of smartwatch or wristband solutions have been proposed (e.g., [2][6][8]). One example is Perrault *et al.*'s WatchIt, a simple input device that allowed for eyes-free interactions on the wrist [6]. While interactions with watch-like mobile devices were previously limited due to small screens, WatchIt extended interactions to the wristband, offering a richer set of gestures to support quick interaction.

Another approach is to use on-body or 3D-gesture input, rather than having the user touch a wearable device. The Imaginary Phone, for example, created by Gustafson *et al.*, invited users to interact with their bare hand and access their phone remotely, freeing them from even interacting with an explicit device, such as a wristband [2]. They argue that the Imaginary Phone has potential due to transfer learning, where a user is familiar with one interface (such as an iPhone) and is able to transfer its layout to his or her palm. Rekimoto proposed two solutions that were designed to provide unobtrusive gestural input: The GestureWrist recognizes hand gestures, and the GesturePad are touch panels affixed to clothing [8]. These explorations of wearable input, human interaction, and mobile devices showcase the developments in eyes-free, unobtrusive technological interactions, but none of the work above explores the implications of such technologies for people with visual impairments.

Also related to our study is work on the social acceptability of wearable interaction. To assess how attitude toward wearable interaction differed by culture (US vs. South Korea), Profita *et al*. created the Jogwheel, an embroidered patch that interfaced with a mobile device, and conducted a survey that included videos with an actor interacting with the Jogwheel [7]. The study collected third party attitudes toward Jogwheel placement on the body and types of gestures. The forearm and the wrist proved to be the most favored of Jogwheel placement, even across cultures.

Improving Existing Accessibility Technologies

Existing accessibility technologies are designed for maximal functionality, but often the social acceptability of these products is overlooked. Shinohara and Wobbrock conducted an interview study asking users with visual and auditory impairments about their accessibility device use [9]. Users disliked using specially engineered accessibility devices because they perpetuate misperceptions about disabilities, and because they are unsexy. As Kane *et al*. have shown, users with disabilities sometimes prefer to use more affordable mass-market mobile devices, even if there are more functional technologies available to them [4]. A major recommendation from Shinohara and Wobbrock [9] is that designers and engineers should either improve accessibility features on current mainstream devices, or create technology that is "designed for social acceptance". If the latter, designers should keep in mind not only the functionality, but also the aesthetics and the perception of future accessibility devices.

Many projects have addressed the accessibility of mainstream mobile devices (e.g., [3][4][5]). To derive design implications for mainstream touchscreen design, Kane, Wobbrock, and Ladner compared gestures between sighted and visually impaired users on the progressively popular touchscreen [5]. Compared to sighted users, blind users' gestures are larger and slower in execution, and vary more in the size of the gesture. The authors recommended that increasing the number of tactile landmarks, reducing the need for location accuracy of gestures, reproducing familiar layouts, such as a QWERTY keyboard, can improve the accessibility of current technologies.

STUDY

Wearable devices have the potential to be unobtrusive and socially acceptable accessibility devices for visually impaired users. To explore the potential implications of such devices, we created an interactive felt wristband that interfaced with an iPad, and designed an interview study with sighted and visually impaired users. To date, we have completed one interview with a blind participant. We plan to interview a total of ten sighted and ten visually impaired users.

Procedure

The study procedure was designed to fit in a single 60-minute session. Each session consists primarily of a semi-structured interview with a set of tasks using the wristband midway through the interview. The first half of the interview focuses on demographic information, accessory (e.g., jewelry) wearing habits, and current mobile device use. Then, we introduce participants to the interactive wristband and have them interact remotely with an iPad using the VoiceOver screen reader software on iOS. Using the wristband, the participants explore the home screen of the iPad, open applications, and use Siri for speech commands. For sighted users, the iPad is hidden so they cannot see the screen. All users can hear the iPad. Our post-task interview probes how such wearable input would impact the participant's mobile device use. Participants are compensated for their time.

The Wristband

Our wristband is primarily made of felt, and wraps around a user's left wrist with Velcro. The main features are three input surfaces: a home button (similar to those on iOS devices), a touch pad for navigation, and a select button. The input surfaces are connected to an Arduino Uno board, which sends keypress signals via Bluetooth to an iPad. The software was written in open-source Arduino, and makes use of the SoftwareSerial and CapSense libraries.

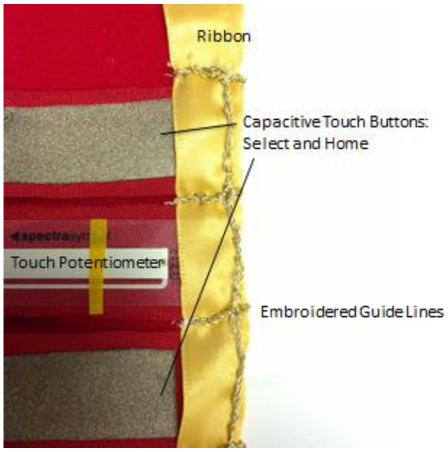

Fig. 2: The ribbon, the embroidered guide lines, and the large capacitive touch buttons are designed with users with visual impairments in mind.

The home and select buttons of the wristband are hand-made, conductive fabric capacitive sensors, 4.5 cm long by 2.0 cm wide. The swipe pad is a touch potentiometer that's 5.0 cm long by 2.7 cm wide. The buttons are mounted on fabric pieces with Velcro to allow for different arrangements of buttons. The wristband has contrasting tactile features to assist people with visual impairments. One such feature is a ribbon sewn along one edge that slightly overlaps the buttons to minimize accidental activation while a visually impaired user feels for the correct button. To help with navigation, we embroidered guide ridges around the buttons so users can orient themselves on the wristband before activating a button.

When a button is touched, the Arduino Uno board sends key press and key release events through the Bluetooth modem, which is paired with the iPad. The iPad recognizes the wristband as a keyboard: When the iPad is in VoiceOver mode and paired with a regular Bluetooth keyboard, users can navigate the iPad remotely, without touching the screen. We exploit this keyboard-VoiceOver relationship by having the wristband communicate as if it were a Bluetooth keyboard.

The current design of the wristband arose from an iterative process of brainstorming, designing, and testing, with user feedback. We initially created preliminary design sketches and conducted an informal eight-person survey with sighted participants about how they would like to wear and interact with a hypothetical wristband. Then, we created a low-fidelity prototypes (Fig. 3) before settling on the current design.

Data and analysis

We audio recorded the interviews and videotaped the participant's interaction with the wristband during the task section of the study. For the single interview reported on here, we transcribed and qualitatively analyzed the interview data using an open coding approach to identify important themes.

Fig. 3: Examples of low-fidelity prototypes created during the iterative design process; these two are made from plastic bottles, fabric, and tape.

INITIAL INTERVIEW

Our participant for the preliminary interview was male, 51 years old, and blind with very little light perception. The participant has had this vision ability for about 20 years. He uses VoiceOver on his iPhone. During the interview, he often drew on his experiences with specially designed mobile devices used in athletic events, such as open water swimming, triathlons, and running.

Privacy and Social Acceptability

In the pre-task portion of the interview, the participant discussed the current privacy issues and social acceptability of using his iPhone and VoiceOver in public. Despite the fact that he dislikes using earphones, the participant uses them to protect his privacy and to avoid bothering others around him. "If I'm in a group of people, and I ask Siri something, it just feels…too revealing…things might come up on a search and it gets all blabbered to a room…there are privacy issues, but it's probably just mostly bothering other people."

At the same time, the participant is not always concerned with others overhearing his interactions with Siri and VoiceOver. He is more at ease to use his iPhone on the bus because it's more "free" there, and because "everyone else is doing it on the bus." But in school and work environments, there are "expectations" that he should fulfill, and feels that he should not be interacting with his phone at work. In academic and professional settings, the participant points out that it is in inappropriate to be, for example, "checking my friends on Facebook." For this participant, the social situation influences how comfortable he feels using his phone.

Ease of Access of Mobile Device

The participant stated that he currently does not have much trouble physically pulling out his phone. He typically carries it in a pocket, and his phone "seems to be there whenever I want it."

Using the phone, however, is a different matter. The participant can quickly pull out his phone, but he reports sometime having trouble navigating to the correct icon on the iPhone. He is uncomfortable using his phone on the go, explaining that there are both situational and physical barriers. The participant states that using his phone while on the go “takes me away from concentrating on what I’m doing.” Then, he illustrated an example where it’s dangerous to be distracted: “I’ll get to a corner and…I won’t remember to stop or listen for cars coming.” He also has to use two hands to interact with his phone, which is difficult to do when he uses his guide dog or cane.

In the post-task portion of the interview, the participant expressed that the wearable would immediately enhance his ability to use his phone on the go: “It feels less restrictive…it would give me more freedom…” He described a situation where he could be walking with a guide dog but touching his wrist, which highly contrasts the current difficulty of using his phone with a dog and cane. If a wearable such as this wristband were available for use, the participant stated that he would use his phone even more.

The participant also voiced a disadvantage of a wearable device: that it requires keeping track of yet another external accessory. In fact, he dislikes using glasses because of the possibility of breaking and losing them. He emphasized the need for *freedom* in the interview; during our discussion of different wearable systems, he most preferred the idea of using a device-less, on-body system (e.g., tapping one hand to the other), yet he was still concerned that such a system “…might impose restrictions on how you move.”

In general, his answers during the post-task interview did not focus as much on whether the wearable would improve his privacy, which seemed to be a large theme in his pre-task interview. The wearable would afford him a “little” more privacy and it “might” enable him to search the internet on his phone in others’ presence.

Physical Design of Wearable Device

In terms of the physical design of the wearable, the participant commented multiple times on how *light* the device was, and if there were wearable devices for other parts of the body, he would like them to be similarly lightweight. He also expressed his dislike for accessories that were tight. Last of all, he suggested several improvements to the current device, including varying the texture even more on the ribbon and the embroidery to make locating the buttons easier.

DISCUSSION

In this preliminary interview, we discovered that the participant’s use of the iPhone is highly dependent on the social context, as well as the level of privacy of his interactions. He has little trouble physically accessing his phone, though interacting with the screen is more difficult when on the go. Subsequent iterations of this study with other participate will inform us whether the themes discovered in this preliminary interview persist across other visually impaired users, or even sighted users.

The biggest limitation of the current study is that the prototype is not wireless—it connects wirelessly to the iPad, but is wired to the external Arduino controller, which in turn is plugged into a wall outlet. As a result, the participant had to sit at a table to interact with the wristband, which might have prevented the participant from experiencing how a device would help him while on the go. As well, we used the iPad’s built-in speaker for the VoiceOver audio rather than providing an earpiece, which may have affected our participant’s perception of privacy with a wearable.

FUTURE WORK AND CONCLUSION

Our preliminary interview indicates that wearable technology offers great potential to impact the accessibility of mobile interaction for people with visual impairments. In future work, we plan to create a wireless version of this wristband with the tactile design changes suggested by the participant. We hope such changes will streamline interaction for users with visual impairments. This new version would also be less prone to accidental activation and would be more robust, allowing us to evaluate the wristband in a truly mobile context.

Furthermore, future studies should not be limited to a wristband prototype. To expand this exploratory investigation, we would create prototypes of wearables for different parts of the body so participants can more fully discuss the potential of wearable devices. Another broader direction arises from the participant’s experience with specially designed wearable devices for athletic events, which suggests that there should be investigation into the accessibility of such technologies.

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