Wearables for All: Development of Guidelines to Stimulate Accessible Wearable Technology Design

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ABSTRACT

In this paper, we present the rationale and approach for establishing guidelines for the development of accessible wearables. Wearable technology is increasingly integrated in our everyday lives. Therefore, ensuring accessibility is pivotal to prevent a digital divide between persons who have and persons who lack access to these devices, caused by their abilities. We present a project in which guidelines are created that enable developers to design accessible wearable apps and technologies. These guidelines will be created with developers who have experience with designing accessible technology and/or wearables. In addition, users who (potentially) experience problems with accessibility of wearables (persons who have a disability) are involved in the development of the guideline, to ensure their validity from an end-user perspective.

CCS Concepts

• Human-centered computing~Accessibility design and evaluation methods

• Human-centered computing~Accessibility technologies

Keywords

Wearables; wearable technology; design for all; universal design; developer guidelines; accessibility; visually impaired people.

1. INTRODUCTION

Wearable technology increasingly mediates information-sharing and communication. Public and commercial agents offer services using these devices that range from health-related monitoring and advice to online shopping, wayfinding, navigation, and communication services. Wearable technology potentially gives people with visual and other sensory disabilities better, less conspicuous, and easier access to information and services. The advantage of wearable technology is that they enable users to collect, process, and transfer data even without (strenuous) interactions with the device. Wearable devices are usually worn on or near the body and since they do not need to be actively held or carried (like a smartphone), they leave both hands free. Operating the system sometimes requires touch, but often movement, gestures, and voice commands can be applied as well. Output can be visual on a screen, but also through (a combination of) sound, spoken words, vibration, movement, temperature change, small shocks, etc.

A combination of different in- and output modalities make up the multimodal interfaces that many wearables have. This multimodal interface, combined with the hands-free, wearable, and mobile character of wearable devices make them especially interesting for persons with a disability. Many different assistive devices are available for people with disabilities. These devices support distinctive tasks such as scanning text, providing refreshable braille, wayfinding, or object detection [23]. However, these assistive devices have certain drawbacks in comparison to the wearable technology we focus on in this paper. The range of tasks that a certain assistive device supports is often limited. This requires persons to carry with them various devices in order to be supported throughout the day. Furthermore, assistive devices can be rather stigmatizing. For example, blind people can use a bright yellow infrared device, which needs to be pointed forward and which beeps loudly when it detects an object. On the one hand, this device will help blind people from bumping into objects. On the other hand, persons with a disability do not always want to be identified as such. Lastly, keeping various assistive devices up to date with new releases can be cumbersome. These disadvantages can be summed up as; too bulky and too many to carry, stigmatizing, and inflexible regarding technology updates. Wearable technology, on the other hand, has the potential to support a great variety of tasks [23]. A quick scan through smartphone application stores, searching for applications for visually impaired people (VIP), renders a multitude of generic and dedicated apps that assist blind persons in daily tasks. These tasks include navigation and wayfinding, text to speech conversion, and object and text recognition. As argued before, wearable devices have a similar potential, with the advantage of facilitating hands-free support.

The hands-free advantage of wearables is only valid when the devices, applications, and content are designed to be accessible. Inaccessible systems and content lead to systematic exclusion of groups in society [11, 12]. For example, smart glass interfaces that offer no alternative for visual output withhold functionality that relies on visual display for persons who cannot see the display. Likewise, alternatives for touch input of smartwatches are necessary for persons who have impaired fine motor skills. When

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persons lack access to information and communication technology (ICT), this results in inequality, less participation of these groups in education and work, and a higher dependence on others or public support [16, 26]. This can cause a so-called digital divide; people who lack access to ICT cannot fully participate in society (e.g., because they lack material means, motivation, or ability to use ICT). As a result, they can get isolated, or lag behind in terms of socio-economic status [8, 18]. As wearables, like smartphones, are increasingly integrated into people's everyday lives, not having access to them might increase the digital divide [27]. Moreover, wearables may assist persons with a disability to participate in activities that would otherwise be difficult for them. For example, Dibia and colleagues [7] explored if and how wearables can assist persons with mild cognitive impairment in a work environment. They describe various use cases and conclude that wearables have the potential to address issues which currently prevent these persons from participating fully in a work environment.

In order to prevent a digital divide caused by inaccessible wearables, more attention to accessibility should be paid during the development of wearable technology. In the following paragraphs, we discuss approaches that can support this, and introduce our project which sets out to create guidelines for the development of accessible wearables.

2. GUIDELINES FOR WEARABLES

2.1 Design for All

To ensure a match between the technology and all potential users, developers can work according to inclusive or universal design approaches [1, 19]. This means that user interfaces should be constructed in such a way that they are "suitable, or capable of being easily adapted, for all people, even if a number of users would need special equipment to use them" [1]. Universal design principles [20] further specify the way designs can be made accessible to the broadest range of users. The principles focus on providing access and usefulness to a broad range of people, with diverse abilities. The design should be flexible to accommodate individual preferences, and it should be simple and intuitive in use. Further, information should be perceivable by all users. The system should also minimize hazards and errors and should cost low physical effort. Lastly, appropriate size and space for approach and use should be present in the design [20]. These principles hold some overlap with and are related to the topic of usability, since good usability (for certain user groups) enables users to consistently and easily use the technology. However, universal design includes and acknowledges the variety of abilities and circumstances of various users and provides an approach to become aware and deal with them.

Accessibility, like usability, calls for a human-centered design approach. Involving (a wide range of) end users during development cycles to learn what their need, abilities, and wishes are, forms an good basis to ensure accessibility of wearables. Key principles to human-centered design are "the active involvement of users and understanding of user tasks and task requirements, […] an appropriate allocation of function between user and system, […] and iteration of design solutions, […]and multi-disciplinary design teams" [14]. In addition, important issues to take into account are: who are the persons that are placed at the center of the design process? What characteristics and abilities do they have, and do these include persons with a disability? How can they be involved in the development process? Should extra attention be paid to the variety of abilities the user group may have, how does this translate to HCD activities involvement? An example of user-involvement to create accessible wearable technology is described in [22]. In this study, researchers involved VIP from early design stages on, to observe them and, eventually, co-create wearables to support cognitive mapping and landmark identification [22].

2.2 Available Guidelines

The current project aims to develop and validate accessibility standards for a new generation of wearable ICT devices, such as Google Glass. A human-centered design approach is taken, to ensure that the design guidelines match both designer and developer needs, as well as VIP needs and wishes in wearable technology solutions.

Currently, various standards, guidelines, or advisory documents that support developers in creating accessible websites, multimodal interfaces, or devices exist. Legislative documents and guidelines that focus on the procurement of accessible technology are available [24, 25]. However, as these often focus on the (organizational) processes, evaluation of technologies or products, or legal backup to enforce accessible design of products and services, such documents are often of little help to the developers of applications and devices. On a more practical level, web accessibility receives a substantial amount of attention. An important source of information and guidance is the web accessibility initiative by the World Wide Web consortium (W3C) [5, 10]. It focuses on establishing and communicating standards for web accessibility. W3C describes accessible design in the Web Content Accessibility Guidelines (WCAG) as design that enables the user to 1) perceive the essential content, 2) operate all features and perform all interactions in the desired communication mode, and 3) understand the content and the device. Thus, it should be easy to (learn to) understand and apply the information and device [6]. Similarly, guidelines for accessible agents, browsers, non-web content, and multimodal interfaces exist [2, 13, 17].

Surely, accessibility is not limited to web-based applications (such as webpages). Smartphones and wearable technologies support the exchange and use of data wherever we go. Disability modes for smartphones are available for some types and brands. Developers for mobile technologies have more (IOS) or less (Android) access to developer guidelines to enable accessibility features in their products [3, 4, 11]. For wearables targeted at a broad public, such as Google Glass or Apple Watch, some accessibility features are available. However, these modes often fail to open up all functionalities to persons with a disability. In fact, often, the accessibility features appear to have been added later on, as an extra (additional) service, rather than an intrinsic and core aspect of the product. It is important to note that accessibility issues apply to the devices and their native platforms (e.g., iOS, Android, Windows, etc.), as well as the applications that are developed for these devices. With accessibility features integrated in the device and operating systems, accessibility of basic functions can be enabled. However, app developers do not necessarily use the accessibility options that are built into the operating systems (e.g., captioning to enable voice commands and text-to-speech output). Conversely, application developers can create accessible applications on platforms that do not support a broad range of accessibility features. Lastly, wearable technology is often connected to a mobile application or website, where settings can be changed or data can be managed. In these cases, not only the wearable technology but the supporting technology should be accessible as well. In our view, ideally, devices and operating systems support accessibility features, and app developers include these functionalities in their applications.

A universal design approach to wearable technology development and evaluation is described by Tomberg and colleagues [21]. In this approach, the principles of equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, size and space for approach and use [20] are discussed within the context of wearable technology.

The aim of this research is to enable developers to take accessibility into account in early development phases and throughout their development projects. More specifically, we aim to integrate the available documentation, standards and guidelines, and developer experience to provide support for developers in the specific domain of wearables.

2.3 Project Approach

In this project, we combine the views of technology users (with a disability) with expert (developer) experiences. With the set of guidelines we develop, we primarily target developers and designers of wearable technology and applications.

First, a scan of the literature is done. Available guidelines and other publications offering recommendations or guidance are reviewed for their applicability to developing and designing wearable technology. An additional focus is placed on publications that address multimodal interfaces. Simultaneously, developers and researchers (of accessible wearables) are interviewed to learn on which guidelines and own experiences they base their design decisions. Relevant documentation and experiences are used as input for a draft set of guidelines. Based on the literature study, and developer interviews, a draft set guidelines, formulated as design principles, is created.

Hereafter, the draft guidelines will be evaluated with developers and researchers who have had previous experience in developing multimodal interfaces for wearable technology and/or accessible technology. These evaluations are done by means of a Delphi study [15] in which respondents are invited to comment and refine the guidelines in multiple iterative rounds, via email. Persons with a disability are simultaneously invited to partake in this Delphi, to ensure an end-user perspective as well.

Lastly, the refined guidelines will be tested against the product of various accessible wearable technology projects, including related (externally funded) projects. In these projects, applications are developed for smart glasses and wearable technology for smart environment wayfinding, aimed at VIP. The applications stemming from these projects are assessed on accessibility and compliance to our guidelines. Retrospectively, guideline components that have likely led to accessibility or inaccessibility will be identified. Besides these related project applications, we aim to include as many additional applications or wearables as possible in this evaluation, depending on availability of information and testing opportunity.

2.4 Preliminary Outcomes

Based on a first literature scan and experiences from previous projects, we formulate various principles that will be refined throughout this project. First, we stress the importance of two basic principles for accessible wearable technology and applications:

1. Use multimodal presentation of information to allow users with different preferences and abilities to use information in their preferred way [9].
2. Use multimodal interaction to allow users to interact with a system following their individual preferences and suited to their personal needs [9].

In addition, the system should provide adequate feedback to its users. Therefore, a third principle is added:

3. The system or application should provide relevant feedback on the user behavior and the system actions. This can consist of positive confirmation and reinforcement of actions, and/or status or process updates, or notification and instructions on unexpected or incorrect behavior or actions.

To accommodate the changing preferences of users in various settings, the system settings should be adaptive and/or adaptable. The following principle is formulated:

4. Adaptation of preferred settings (e.g., for input/output modalities, feedback intensity) should be contextual; based on localization, task, and/or user preferences. The system should be self-learning to enable optimal automated adaptive settings.

These draft guidelines are refined based on the outcomes of the formal literature review and interviews and Delphi study.

3. DISCUSSION

In this paper, a project approach is described for the development of design guidelines for accessible wearables. Both developer and designer input, as end-user opinions on the guideline as well as user evaluations for accessibility of actual applications are taken into account to create these guidelines.

3.1 Call for Participation

We invite researchers and developers who have worked on projects in which accessible wearable technology or applications were developed, to take part in this study. Especially persons who have taken part in a systematic evaluation or case studies of wearable systems, or who have analyzed or evaluated the problems and solutions of users with disabilities are invited to participate in the

Delphi study. This study will take place between the months of April-September 2016, participation is possible at any moment within this timeframe. To participate, please send an email to the corresponding author (JW, m.j.wentzel@utwente.nl).

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