Rehabilitation Engineering Research Center for Wireless Inclusive Technologies

Research Brief #17-01

Accessibility, Usability, and the Design of Wearables and Wirelessly Connected Devices [1]

Executive Summary

Wearables, "smart" home, and other next-generation wirelessly connected devices for work, home, and leisure continue to increase in popularity. As augmentative tools for work and living enhancement, and social participation, these technologies should be not only usable, but also be *accessible and inclusive* for people with disabilities. Researchers at the Rehabilitation Engineering Research Center for Wireless Inclusive Technologies (Wireless RERC) have conducted a review of representative applications and examples of currently available wearable and connected technologies. Drawing on the findings, we explore the potential impact of inclusive design principles on future device development for users with disabilities – a critical approach for ensuring that these technologies truly meet the needs of this target population. People with disabilities are beginning to be an integral part of the development of technologies and applications to 1) enhance accessibility, 2) increase independence and community participation, and 3) support a more inclusive society, a trend which we feel will increasingly become the norm in the future.

Introduction and Background

The Wireless RERC at the Georgia Institute of Technology (Georgia Tech) was established to research and develop approaches and technologies which integrate emerging wirelessly connected devices, sensors, and services with established wireless technologies for a transformative future where individuals with disabilities achieve independence, improved quality of life, and enhanced community participation. The Wireless RERC is undertaking foundational research to determine how wireless technology and social and cultural design approaches affect adoption or rejection by users with disabilities. The RERC's User Experiences and Expectations Research project generates empirical evidence on the ownership and use of IoT devices, including wearables, user interfaces, and smart home devices, as part of the ongoing *Survey of User Needs*. This research is complemented by another Wireless RERC project, Social and Cultural Design Research which investigates how IoT design and its responsiveness to social and cultural expectations affect adoption or rejection by users with disabilities.

The evolution of wireless technologies has spanned several decades, from providing simple connectivity to offering powerful tools to enhance community engagement, participation, and self-determined living (Atzori, Iera, & Morabito, 2010; Jara, Zamora-Izquierdo, & Skarmeta, 2013). Wireless connectivity fuels a new generation of "smart" and connected objects with assistive potential, ranging from wearable computing devices (wearables) worn by individuals to physical objects in the environment such as sensors and specialized displays to deployment in smart cities (Neto, et al., 2018). We refer to this connected ecosystem by the common term "Internet of Things" (IoT). There are now billions of connected devices in the United States, and they offer useful applications such as home automation, security, and management of daily tasks (CISCO, 2017; Ferati et al., 2016). IoT, most broadly, can connect people with disabilities with their work, home, and other environments for connectivity, monitoring, and environmental

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control, which, in turn, can support employment, community participation, and health and function (Domingo, 2012). The design of these devices and services currently remains largely open and unfixed, thus presenting opportunities for the active involvement of people with disabilities, alongside designers, developers, and manufacturers, to address unmet social, cultural, and technical needs (Baker, Gandy, & Zeagler, 2015). Such an inclusive design process can proactively address such issues as technology abandonment or discontinuance while enhancing reception of these technologies as socially acceptable and appropriate (Parette, Huer, & Scherer, 2004; Scherer, Adya, Samant, & Killeen, 2011).

Wearables Technologies and Applications – Promising Examples

Although not specifically designated as "assistive technology," per se, wearable devices, sensors, and supporting applications nevertheless can act in assistive and augmentative capacities to facilitate the social inclusion and participation of people with disabilities (Gandy, Baker, & Zeagler, 2017; Wei & Lo, 2006). For example, by using sensing devices and monitoring hardware and software, it is possible to measure gait speed, a significant predictor of life expectancy for older adults (Studenski et al., 2001). Drawing on patterns evident in data can allow a smart environment (or even caregivers) to adapt to the needs of the associated users. Other intelligent devices—smart headsets, glasses, watches, bracelets, and more—are finding their way into our daily lives. Wearable computing devices such as the Apple Watch and Android Wear currently represent the best-known applications of wearables and their potential for users with disabilities (Ferati et al., 2016). Other popular examples include the Fitbit and Jawbone wearable fitness bracelets, which have been available for several years and commanded the bulk of market share (Kerr, 2014). Less intrusive technologies, such as jewelry, buttons, clothing, and even implantable technology exist and are finding commercial applications (Martin, 2014). These health and fitness devices and applications could eventually become "lifestyle remotes," helping users with disabilities control or automate many other systems around them, regardless of whether they are in their homes, offices, or cars (Tsukayama, 2014).

An extension of IoT-based "smart" home technologies uses home networks and cloud-based connectivity to enhance independence and community participation. Currently, available voice assistants, such as Amazon Echo, Google Home, and Apple HomePod can enhance independence for certain disability groups augmented by the potential of programming of "skills" to offer using device programming for control, sensing, and display. Other examples include accessible navigation systems (Saaid, Ismail, & Noor, 2009) and obstacle detection based on voice-synthesized instructions (Martin et al., 2009) for blind and low vision users. People with hearing-related disabilities may benefit from wearable displays to access graphical information and text normally presented in auditory formats. People with mobility-related disabilities also can benefit from technologies such as head-tracking signals for tilt-based control of home appliances. Researchers are investigating facial detection, eye-movement control, brain control, gesture recognition and facial expression recognition for similar purposes (Ju, Shin, & Kim, 2009). Inclusively designed, smart home applications are highly capable of improving the autonomy and self-confidence of people with disabilities (Lanigan et al., 2006).

Accessibility/Usability Considerations for Design and Development

Designers and developers frequently focus on usability, but often lack an appreciation of the nuances of *accessibility* and the needs of persons with disabilities. Insights gained from employing an *inclusive* design process can facilitate the training of future designers and encourage responsiveness to the needs and preferences of users with disabilities while disseminating enhanced methods for effective design. A participatory design process that proactively engages people with disabilities should be employed throughout the design and development phases. From a policy standpoint, accessibility of future technologies also should become a high-level consideration when planning national technology development strategies and policies. Market-driven approaches can enable users to provide input into the device design process, in concert with traditional options. Users with disabilities should be utilized as participants in the broader deployment process rather than simply being subject to technological change (Gandy, Baker, & Zeagler, 2017). Integrating universal design (UD) approaches into development may reduce the need for retrofitting for accessibility while opening up new, and unexpected solutions with broader market utility. UD may not be sufficient to address social and cultural concerns and the accessibility needs of users with disabilities, but—in tandem with inclusive design involving people with disabilities— it may reduce development costs while allowing for new and better methods to emerge (Schulz et al., 2014). Ideally, inclusively designed IoT integrates design thinking and policy development approaches to generate more cost-effective, flexible, responsive technology outcomes for people with disabilities (Gandy & MacIntyre, 2014). By promoting design that is both *usable and accessible*, technology will better address user needs, and bridge the current gap between what is available and what is needed.

Current and Future Research

The Wireless RERC is investigating social and cultural design factors for wearable display, sensor, and input/output (I/O) to produce future wearable authoring tools to support wireless technology development for people with disabilities. Wearable technologies offer possibilities that transcend the passive sensing of current fitness trackers and health monitors by augmenting the abilities of users and assisting them throughout their daily lives. Wearables may offer contextually aware, just-in-time information or support for primary tasks ranging from using public transportation and working on an assembly line to meeting friends at a restaurant. Currently available devices offer few, if any, input and output (I/O) options for users with physical disabilities. However, smart clothing, implantables, and unobtrusive multi-modal display "accessories" could offer users with disabilities more non-intrusive IoT choices. RERC research allows participants with disabilities to experience potential wearable services as part of the prototyping phase, which will lead to development activities in the RERC's Wirelessly Connected Devices development project to create new wearable I/O devices (display and/or user-interface) that are accessible and contextually useful. After prototype development, the project team will engage in activities to determine the appropriateness of two tested and refined wearable devices in public Internet of Things (IoT) settings and Whole Community environments. The focus will not be on particular "devices," but rather, on the types of wearable "services" that support what users with disabilities will require or desire.

Conclusion

Many companies and organizations focus on IoT usability to varying degrees, including device and handset manufacturers, networks, and application developers. To create an IoT that works for everyone, inclusive accessibility also must be a consideration during each stage in the design and development continuum. Active user involvement becomes particularly important when designing applications to be used by people with disabilities due to specialized user requirements as well as applicable regulations, standards, and guidelines (Newell et al., 2011). If industry stakeholders incorporate universal design *and* inclusive design that involves the active participation of people with disabilities, wearables, "smart" home devices, and other IoT objects and services will offer greater independent living, more personalized care, more flexibility and mobility, and better employment and education outcomes through next-generation wireless technologies.

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