The Need for Research on Mobile Technologies for People with Low-Vision

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Abstract
We argue that there needs to be more research on technologies for people with low-vision. While the vast majority of people with vision impairments have some functional vision, accessibility research tends to focus on nonvisual interaction. Researchers can make mobile devices more accessible to low-vision people by exploring target acquisition, text entry, and text and image output for this group of users. Researchers can also use mobile devices as tools to better enable low-vision users to access printed material and signage.

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Low-vision, mobile accessibility.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Much research has been done in the last several years about mobile technology for people with vision impairments. Almost all of this work has focused on nonvisual access, ideally suited for people with no functional vision. People with low-vision (LV), however, who have functional vision, may find advantages in

using their vision when interacting with technology and accessing information in the world. As such, in this paper we argue that there needs to be more research on mobile technologies for people with LV who can utilize their vision to be more efficient and effective.

Our views are based on our collective years of experience conducting research with and for blind, LV, and deaf-blind people (dating back to 1984). The first author of this paper has LV and offers insight gained from first-hand experience as well. Thus, this paper is a rhetorical piece and not a report of original research.

Background and Demographics

LV is defined broadly as a visual impairment, which cannot be corrected with contact lenses or glasses, that adversely affects a person's daily activities [7]. Since vision loss can be caused by a variety of eye conditions, a person with LV may experience different symptoms including blurred vision and loss of central of peripheral vision.

National and global statistics overwhelmingly indicate that (1) vision impairments are prevalent, and (2) the vast majority of people with vision impairments *have* functional vision. According to the World Health Organization (WHO), about 285 million people worldwide have a vision impairment and only 39 million are blind [10]. In the United States, it is estimated that 21.5 million people "have trouble" seeing with best correction and only 1.3 million (6%) are *legally* blind. Even legally blind people may have functional vision, so the proportion of blind people who can benefit from LV technologies is probably higher than these statistics imply.

LV is especially common among people living in developing countries and among older adults. The WHO reports that about 90% of people with vision impairments live in developing regions, where mobile phones are far more available than specialized LV aids [7,9]. Older adults commonly experience vision loss from various diseases including diabetic retinopathy and macular degeneration. As the baby-boom generation ages, the number of older adults with vision impairments is projected to increase substantially [3]. An LV research agenda should therefore target older adults and people in developing regions to support these demographics.

Literature Review

We conducted a literature review to quantify the amount of accessibility research on LV as opposed to blindness. The review covered papers and posters from a sample of HCI and accessibility conferences, including ASSETS, CHI, UIST, and MobileHCI from 2009 to 2012. We found 73 papers and posters relating to people with some kind of vision impairment. Among those, only 4 papers and 4 posters (11%) addressed LV issues specifically.

Hayden et al.'s work on Note-Taker 2.0 [4] was the only full paper we found that presented an innovation for LV people. Other papers included LV people among those with other disabilities. Montague et al. [6] proposed adaptive interfaces for people with diverse visual and motor abilities. The remaining two papers, Kane et al. [5] and Shinohara and Wobbrock [9], conducted studies that investigated people's attitudes and experiences with technology, including people with LV among their participants.

Figure 1. Entering text and viewing a map with the iPhone Zoom [1] magnifier. Only a small part of the screen is visible, making interaction very difficult.

The remaining publications among the 73 we found primarily focused on blind people and nonvisual interaction. It is paradoxical that while the vast number of people with vision impairments have functional vision, nearly all the work covered in our review focused on nonvisual interaction. In the next section, we suggest possible causes for this discrepancy.

Reasons Low-Vision is Overlooked

We speculate why LV is rarely addressed by the research community, hoping to inspire reflection and change among our community.

LV is complicated. There are many eye conditions that affect people's vision in different ways and to varying degrees. In contrast, a lack of vision is clearly defined and easy for researchers to understand.

LV is "invisible." People with functional vision may appear fully sighted and not in need of assistance. Blind people tend to be far more noticeable, so even though their numbers are smaller, their presence attracts more attention. Yet people with LV face daily accessibility challenges as well.

Magnification is perceived as a one-stop fix. There seems to be a misconception that magnification can fully alleviate LV access problems. Typical screen magnifiers uniformly enlarge a portion of the screen (e.g., iOS Zoom [1]). Yet, while these magnifiers enable a person to visually process the screen's content, they can hinder efficiency and increase error and frustration.

As a result of the above, we believe that far more research is needed to (1) understand the challenges LV people face and (2) invent and evaluate tools to address these challenges. Our community should strive to enable *optimal* access to information, increasing efficiency and reducing error and eye strain.

Future Research Directions

We highlight challenges for future research on mobile LV technology. As with research for blind people, there are two overarching goals: (1) making a mobile device more accessible and (2) making one's environment more accessible using the mobile device as a tool. We discuss each goal below.

Mobile Devices Accessibility

Simply magnifying a portion of a device's screen is problematic for basic mobile tasks such as entering text or reading a map (see Figure 1). Magnification results in loss of context and requires users to pan the viewport around continuously. Other simple transformations, such as increasing font sizes or contrast levels, merely scrape the surface of methods that increase visual functioning.

To optimize LV access to mobile device interfaces, we propose exploring the accessibility of specific tasks such as text entry, target acquisition, and text and graphic perception. Text can be enhanced by dynamically changing its format, font, color, and size according to its current relevance to the user. Images displayed on the screen (such as photos, icons, and graphs) can also be modified, instead of simply magnified. Computer vision techniques such as edge enhancement can improve intelligibility. Speech can be incorporated, but selectively. Due to the wide range of vision impairments, the most effective interaction techniques will probably have to be adaptive.

Accessibility via Mobile Devices
Mobile devices with cameras are ubiquitous and in the future the camera will likely be programmable [2]. These capabilities along with modern computer vision techniques give the potential for new mobile solutions to access problems of two varieties: (1) access to signage like street signs, message boards, and other information that may be difficult to read and (2) access to nearby information that can be touched and manipulated such as restaurant menus, sheets of paper, books, and information on products, like on medicine bottles. Access to signage has at least two components, finding the signs with a camera with a limited field of view and enhancing the information to make it larger and more readable on the small screen. Access to nearby information which might be a barcode or text has the advantage that the camera could be fixed and the object to be read can be manipulated. For example, the nutrition information on a box of cereal can be found by rotating the box and keeping the camera relatively stable. Once the information is found in a video stream, computer vision algorithms could remove blur by combining multiple blurry images, then enlarging the image to obtain a readable image on a small screen. Computer vision algorithms can thus replace expensive specialized "LV aids" such as CCTV's.

Conclusion
Research for people with low-vision has largely been neglected by the accessibility research community. We hope to inspire the community to explore ways to (1) increase LV access to mobile devices and (2) to use mobile devices to increase access to an LV user's environment. As the demographics suggest, there is a compelling need to focus on older adults and people living in developing regions with LV. By supporting LV people, there are many opportunities to improve universal mobile access and impact the lives of millions of people around the world.

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