What do Low-vision Users Really Want from Smart Glasses? Faces, Text and perhaps no Glasses at all

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Abstract. Recent advances in low cost wearable computers opens up new possibilities for the development of innovative visual aids. A head-mounted display with cameras that capture views of the physical world, a wearable computer can process the image and present an augmented view to the user. Although, some research is reported into the development of such visual prosthetics the functionalities often appear ad-hoc. This study set out to identify what functionality visually impaired users need in various contexts to reduce barriers. Information was gathered via interviews of visually impaired individuals. The results show that recognizing faces and text is the most important functions while the idea of smart glasses where questioned.

Keywords: universal design, low vision, computer-assisted visual aids

1 Introduction

Recent technological developments have opened up new opportunities for providing valuable assistive technologies for disabled individuals. Wearable and mobile computing technologies have become smaller, more powerful and more affordable. General off-the-shelves devices can be applied in various domains through open application programming interfaces. High-speed Internet connectivity gives constant access to vast amounts of information. Tasks requiring heavy processing can be moved to the cloud. Consequently, innovative and exiting new approaches are emerging.

However, the technical focus may divert the attention away from the needs of users. This study addresses the most prominent needs of individuals with low-vision. Semi-structured interviews were used to identify their functional needs. These needs are discussed in relation to the current research on computer-based visual aids. The results suggest that there are gaps between the research and the actual needs.

2 Related work

The idea of smart glasses goes back more than 20 years with the early work of Peli et al. [1] who studied basic image processing for image enhancement. In particular, Peli et al. studied the visually impaired individuals' recognition of faces [2]. Everingham et

adfa, p. 1, 2011.

al. [3] used a technique to identify objects in images and colour these using saturated colours. Users are thus made aware of objects that otherwise are blurred or blend in with the background. Harper [4] explored a head-mounted image magnification device.

More recent works based on state-of-the-art hardware include Zhao et al. [5] who experimented with magnification, contrast enhancement and on-the-fly optical character recognition. A similar attempt was made by Kálmán et al [6] who addressed automatic light and contrast enhancements and augmented edge enhancement. They also marked pedestrian crossings and performed traffic light detection. Tanuwidjaja et al. [7] implemented a colour adjustment system for google glass to counterbalance colour-blindness. Google glass has also been used for edge enhancements [8]. Hicks et al. [9] explored a device that exploits partially sighted users peripheral vision and adds depth information to nearby objects by making them brighter.

Lab systems have demonstrated concepts including obstacle detection based on stereoscopic images [10] and radar based indoor navigation [11]. Vision systems without displays have also been explored including Merino-Gracia et al.'s [12] head-mounted camera system for real time text recognition with text-to-speech audio.

Most of the studies on smart glasses seem to be based on assumptions about low vision. Dougherty et al. [13] identified that low-vision devices are not used by the target group. On reason for this abandonment could be that the devices do not match the users' needs. Satgunam et al. [14] studied whether users find contour enhancements useful. They concluded that moderate enhancements may help, but more research is needed. Luo et al. [15] explored the effectiveness of augmenting large visual fields onto smaller regions for individuals with reduced field of view and reported positive effects. A few documented qualitative studies address the functional needs of individuals with low vision. One of these is Cimarolli et al.'s [16] study of older individuals. They found that the main challenges are connected to transportation, recognizing people in a social settings and psychological issues. This study thus attempted to further identify the functional needs of individuals with low vision as a basis for developing more useful low-vision aids.

3 Method

Three visually impaired academics in their 40s, 50s and 70s, two male and one female, were interviewed using a semi-structured guide. Two of the participants had low and very low vision from birth, respectively. The third participant had uncorrected vision for most of his life, but was diagnosed with retinitis pigmentosa (RT) in his fifties, with a current tunnel field of view of about 1 degree and no colour vision.

The goal of the study was presented to the participants and they were asked to ignore issues related to personal computer use and issues in at home. This is because the both personal computers and the home were considered controllable by the individual. The participants were asked to focus on issues beyond their control. The interviews were conducted in Norwegian and the quotations herein are simplified translations.

4 Results

The interviews revealed three particular problem areas, namely recognizing faces, recognizing text and the stigma of visual aids. These issues and their related coping strategies are discussed in the following sections.

4.1 Recognizing faces

Recognizing faces emerged as the most emphasized issue. Social interaction depends on knowing with whom one is interacting. The reduced ability to recognize faces often leads to an experience of relational asymmetry where only the non-visually impaired part knows who the other person is. Moreover, the non-visually impaired person may be unaware of the other person's low-vision. Even if they know, they may not realise the consequences. A person who is trained to interact with low-vision individuals may say "Hi, it is John here", while most people may not realize the importance of such cues. This effect may be strengthened by the fact that low-vision individuals' often try to give the other person perceived eye-contract as one learn from an early age that eye contact is key to successful social interaction. This eye contact is often one-directional where the low-vision individual will look in the direction of the voice. This may give a biased impression of the interaction quality.

One participant commented that he had a former career in radio journalism where he listened to and perceived people's voices. He claimed to have trained his listening abilities, by listening to the timbre of the voice, modulations, choice of words and manner of speaking. He was able to identify people he knew directly from their voice, and only on a very few occasions was he unable to determine who the other person was. He also pointed out that he moved slower and used a white cane to signal his low vision, "I do not want people to think I am intoxicated from how I move".

Several examples of challenging situations were mentioned such as meeting with people approaching from afar. To recognize a face the person needs to be at close proximity before the low-vision individual can identify the person. One coping strategy is to recognize the clothes, a distinctive coat, a certain shape handbag or backpack, big hair or the gait of the approaching person and seeing if the person is walking in a path towards oneself. However, this strategy fails completely in situations where the person is wearing something unusual, such as on a special occasion or party. The participant with RP often experienced clearly seeing a nose, an eye or hair colour, but that this was enough.

It is customary to greet another person with a wave of the hand, sometimes combined with a verbal greeting. If there is no verbal greeting the low-vision individual may miss the greeting completely and be completely unaware that they are approaching someone they know. The chance of missing a greeting is more prominent with crowds. The other person may become insulted and think the low-vision individual is being arrogant. A verbal greeting from afar can also be challenging if the low-vision individual do not recognize the voice of the person. Is the person greeting me? One coping strategy is to respond to all verbal greetings regardless. Responding to greetings intended for others is embarrassing.

An acquaintance may suddenly pop, for example on the tram, with "How are you?" One respondent's copying strategy is simply to respond: "Who are you?" Such responses may be perceived as being impolite and abrupt. Another respondent's coping strategy was to pretend to know the person and use general phrases in the initial part of the discussion before identifying the person. The time to recognize a person depends on how socially close the person is. A friend is often recognized from the voice, overall shape and on the general movement patterns, while remote acquaintances are harder to recognize. "Sometimes I didn't know who I actually spoke to".

Indoor situations present other problems. One of the respondents had to network as part of the job, chat with various people at social gatherings and raise issue with unfamiliar individuals. It is challenging to find people in a dark room full of people. The noise level makes it hard to single out a person based on the voice. The participant which was least affected by low-vision presented the following example of a coping strategy. A seminar with prominent people was preceded by a social reception where the goal was to raise an issue with a politician. The respondent sat at the front during the seminar to make mental notes about the clothes and other distinctive signs. Later, he would stroll around and discretely observe people, listen to voices and circle a few rounds around individuals who matched the descriptions to get a better look at their faces before approaching. The participant found these occasions very stressful and challenging. Another respondent totally rejected the idea of social networking in such settings.

The third participant used such occasions actively as a journalist. He has always found it a challenging with gatherings comprising unfamiliar individuals, irrespective of eyesight. He occasionally still attended such events. However, he did so with hesitation without an accompanying person. His coping strategy was not to approach other people, but rather let people approach him while remaining in one place. He viewed this to be a loss as he is as a curious person who enjoys meeting new people. He cited a leader of an RP-organization who said that her greatest loss having gotten RP is that she no longer can see the reactions on people's faces.

When giving talks, he would point out his low vision so that attendees would know to present themselves when approaching him. This participant also pointed out that the size of a gathering is an issue. Gatherings with up to 16 people were unproblematic, while 100 people are next to impossible.

Challenges with social interaction and recognizing faces were also identified by Cimarolli et al. [16] and the mechanisms of recognizing faces has been addressed in the early work by Peli et al. [2]. Beyond that, the research into face recognition aids is limited. This is a paradox as the face recognition research is vast [17]. Could some of these face-recognition techniques be applied in the realisation of useful aids?

4.2 Recognizing text

The recognition of text, especially in the context of transportation, came up as the second most important issue. Having the freedom to move around unassisted is essential for leading an independent and dignified life. Non-moving texts were not regarded too problematic by two participants. One coping strategy is to use a smartphone to take

pictures of the text and explore a magnification. This strategy works well for information boards and display monitors and small print on products in shops. “You can usually take your time” said one participant.

Large airports were commented as being very easy to navigate – the bigger, the better. The person with RP noted that he rarely did air travels without other people, where “at least one person would have better eye-sight than myself”. On the few occasions when travelling alone he would use the guide services offered by the airports. One participant commented that large subway systems such as Paris and London are easier to navigate than the small Oslo subway. The Paris and London subways have colour coded lines and coloured trains matching the lines, while in Oslo the colour coding is not used consistently. All the trains look the same with the same colour scheme.

Information displays on moving vehicles such as busses and subway trains are problematic. It is impossible to see which route number or destination of a bus before it is very close, and if the bus requires the passenger to issue a stop signal it will be too late. As one participant pointed out, “buses and trucks look too similar”. Another participant noted that “it is not possible to use the smartphone camera. It is hard to take a clear picture quickly of a rapidly approaching vehicle, and there is simply not enough time to take the picture, pan and zoom-in on the display. The bus will already have passed by.”

Several coping strategies were mentioned by the participants. One participant reported that bus stops are increasingly equipped with information signs that mostly solve the problem. These are easier to see and can be read with the smartphone, while less important stops often do not have information boards. Occasionally, the boards do not work. Information boards installed by one bus-operator may not show information about buses from other companies. “The metropolitan buses where I live are displayed on the board, while the airport express is not, since it is operated by a different company. It runs less frequent, and I am very worried about missing it”.

Another participant said that the information boards were not useful, and that one strategy was to give a stop signal to all bus-like vehicles, for then to ask the driver. This participant had many experiences of being shouted at by bus drivers. Moreover, some truck drivers had also been angry for being stopped. To overcome this problem the participant had experimented using a white cane as a symbol of visually impairment. However, the white cane had little effect. “I also use the time to guess which bus is arriving, but this is risky since the actual arrival times often deviate from the timetable”. Another participant said that the schedule was his only choice when taking the bus without an accompanying person.

Another issue is that of type of bus stop. One participant stated that “I prefer the small bus stops, because the busses always stop in the same location. At big bus stops the bus may stop anywhere depending on the traffic conditions and other buses”.

The subway poses similar challenges, but results in different coping strategies. “I board the first train that arrives and then figure out from the information board inside which train I am on. I then change trains at the next station if needed. The subway trains have information signs on the side as well as on the front. The side-signs are easier to read, and I tend to stand at a particular spot on the platform to better see them.”

All participants agreed that in-vehicle audio announcements of destinations, and information displays are useful. As one participant said "you really notice the importance of good information boards and audio when travelling to countries without such facilities".

One of the participants relies less on public transport. Instead, he uses a government system where qualifying individuals are allowed a certain number of free taxi journeys. Individuals who find it very hard to use public transport due to disability may apply for this scheme. Obviously, taxis eliminate many of the practical obstacles of getting from one place to another. He also said that he never takes the tram as the main obstacle is to use the automatic ticket vending machines. Taking the train from major train stations however, is less of a problem since they usually have ticket clerks. Likewise, taking buses across the city limits are also ok since drivers sell tickets on-board. It is also hard to pay for the ticket on the airport express train, because it is difficult to find the credit card slot. He pointed out that he needs help finding free seats. However, staff are usually quite happy to assist.

This participant also mentioned problems navigating around a city. "Cities are filled with aggressive drivers that often miscalculate my slow movements". However, his tunnel vision allows him to see the boundary between the pavement and building walls, the street curb and the white zebra crossings, and therefore manages to walk around the city by himself. He navigates by counting streets, and this strategy requires knowledge of the area. "If I lose count, I lose track of where I am. Also, cities do change".

He also noted that it is difficult to enter unfamiliar places as he is unable to read shop signs and find shop entrances. Once inside the problems continue. Often there are stairs going down immediately inside and stairs are difficult with tunnel vision. Finding things inside buildings can be hard without help, for instance finding reception desks in hotels or specific products in a shop.

The issue of transportation has also been identified by Cimarolli et al. [16], and the issue of on-the-fly text recognition devices has been explored by several researchers [5, 12]. The results presented herein support these and similar research efforts. Also, much research have been conducted into the recognition of vehicle licence plates [18, 19]. Could such techniques be applied to aids for low-vision individuals? Although the transportation infrastructure has made enormous advances in terms of assistance to the visually impaired in recent years, the results suggests that there still are some gaps that perhaps could be filled by devices that can help identify arriving vehicles.

4.3 Stigma of unusual-looking equipment

Participants also confirmed the importance of visual aids looking "normal" as there is great stigma connected to "strange-looking" assistive technology. "I do not want to wear ugly things." Recent technology may change this as Google glass, Hololens and Oculus Rift are considered "cool".

The participant with the least reduced vision was quite positive towards the idea of smart glasses, while participants with lower vision preferred audio. "It is very demanding to interpret the visual stimuli as it is, and I would prefer to have information read out such as the name of the person I am looking at or the number of the bus approaching.

I do not bother enlarging the text on my phone or use voice over to see who is calling; I am simply answer the phone and ask – who is calling?" These statements suggest that head-mounted real-time text recognition systems with audio feedback [12] may be a step in the right direction.

The participant with tunnel vision declared that he was not too interested in technology. For example, he had not experimented with talking GPS-devices or modern smartphones. He had traditionally not been too concerned with the appearance of things, but that this awareness has grown over the years. "It is strange…after I lost my colour vision I have wanted to wear clothes with bright colours".

5 Conclusions

This study addressed the needs and coping strategies of low-vision individuals. The results indicate that the recognition of faces is the main challenge for low-vision individuals. Next, the recognition of texts on buildings and moving vehicles is the second most important challenge. Future research into visual aids should therefore focus on developing and testing face and text recognition systems in relevant contexts. Another interesting finding revealed by the interview is whether smart glasses are the solution. Perhaps the solution is non-visual? The results lead to the hypothesis that preference for visual versus audio feedback is related to the level and type of reduced vision.

Acknowledgement

The author is grateful to associate professor Siri Kessel for valuable discussions.

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