

Tele-guidance Based Navigation System for the Visually Impaired and Blind Persons

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Abstract. The design and development of tele-assistance services have taken a great consideration in the domain of healthcare lately. With the growing proportion of dependent people (ageing, disabled users) in the society, tele-assistance and tele-monitoring platforms will play a significant role to provide an efficient and economical remote care. It will allow aged or disabled persons to maintain their independence and lessen the burden and cost of care by caregivers. The concept of proposed tele-guidance system is based on the idea that a blind pedestrian can be assisted by spoken instructions from a remote caregiver who receives a live video stream from a camera carried by the visually impaired persons (VIP). The ICT based assistive tools have acceptance issues by visually impaired persons. It is important while designing navigation tools for the VIP to keep in view the factors that restrain them from the adoption of assistive technology. This paper presents a tele-guidance based navigation assistance system for the VIP and blind persons and reports a qualitative study about attitude of VIP towards technological navigation assistance.

Keywords: Tele-assistance · Tele-presence · Real-time · Navigation · Remote care · Caregiver · Visually impaired · Blind · Acceptance · Qualitative · UTAUT

1 Introduction

Vision loss is a serious impairment that deprives a human of approx. 80–90% perceptual abilities and has a detrimental effect on professional, social and personal quality of life. WHO estimates the number of VIP to be 285 million, majority being over 50 years of age [1]. Even in modern societies, common understanding of blindness and the needs of the VIP are poorly identified. The white cane and more rarely a guide dog are the primary mobility aids that are mainly associated with this disability. In spite of recent remarkable advancements in information and communication technologies (ICT) and electronics, the devices that are termed as Electronic Travel Aids (ETA) are very slowly fighting their ways into the community of the VIP. In fact, no single ETA has been widely accepted by the VIP and blind as a useful aid [2].

ETA is the general term encompassing a large class of assistive devices. The idea of sensory substitution, i.e. replacing lack of stimuli from one sense by appropriate stimuli for another sense is the operating principle of all ETAs [2].

Following is a functional, rather than technological classification of ETAs:

1. Obstacle Detectors
2. Environment Imagers
3. Orientation & Navigation Systems (ONSs)

The first two classes of ETAs are personal (wearable) devices that scan the environment in personal and near spaces. These devices have the task to assist VIP to intercept obstacles on their path. On the other hand, the third group is systems that offer sensing of far-spaces and can acquire data from larger scale distributed networks, e.g. GPS, GIS, Digital Maps, and through wide access to the Internet and wireless communication networks (e.g. RFID, Bluetooth, Wi-Fi, and GSM). An innovative class of ONSs is based on guiding the VIP by a remote human guide termed as Tele-assistance/Tele-guidance systems [3].

The first reported system for remote guidance of the blind was the system developed at the Brunel University, UK [4]. Three ICT technologies were combined to offer the Tele-assistance functionality; namely, GPS, GIS and video/voice transmission over the 3G mobile network. [5] was a Tele-assistance system developed using GPS, Digital maps, Bluetooth, and voice/video link was established over the GSM network within the High-Speed Downlink Packet Access (HSDPA). The system comprised of an ultra-mobile laptop computer worn in a shoulder bag, a digital webcam, and a GPS receiver attached to the shoulder strap, and a single-ear head-phone with a microphone and the assistant who remotely aided the VIP used any PC with a public IP address. In [6], the authors developed a remote guidance system where the VIP was equipped with a digital camera, a GPS receiver and a headset. Internet and GSM connections transmitted video/audio information and GPS data between the remote operator and the user. Similar tele-assistance systems were developed in [7–9].

These systems either used bulky back packs or special purpose mobile terminals to be carried by the VIP. This fact affected the acceptability of such systems by VIP at large. The advancement in computation capabilities of mobile devices and electronics miniaturization presented newer possibilities for developers to develop more user-friendly tele-guidance systems for the VIP. The proposed tele-guidance system enables remote caregiver to assist VIP through voice or vibration using live video feed of VIP's field of view and relative IoT data.

2 System Description

System comprises of two modules, VIP's terminal and remote caregiver's terminal.

2.1 VIP's Terminal

VIP's terminal comprises of four components:

- (1) **Smart Phone:** It provides connectivity with the remote caregiver's terminal. The readily available sensors e.g. GPS, Gyroscope, Proximity sensor and network connectivity are used to provide remote caregiver with real time IoT data about VIP.
- (2) **Bluetooth Webcam:** A Bluetooth webcam connected to the smart phone through Bluetooth connection is mounted on the chest of the VIP. It sends real time video of the field of view of the VIP to remote caregiver.
- (3) **Bluetooth Headset (Earpiece, Speaker):** The Bluetooth head set is used for voice communication.
- (4) **Smart Cane:** The Smart Cane contains tactile braille cell, directional vibrators, and Bluetooth interface. It is being developed as part of this project.

The VIP initiates a video call to pre-configured remote caregiver when in need of assistance. The VIP receives guidance either through voice commands using headset or smart cane's directional vibrators or tactile braille cell. During the tele-guidance session, VIP will be able to mute the voice of the remote caregiver anytime if she wants to make sense of the surroundings by listening proximity sounds. The remote caregiver will get a notification about voice muting. VIPs will be able to configure more than one person as caregiver. If either of those higher in priority is not available, the help call will be automatically handed over to the one available. The selection of caregiver and hand over can also be based on need based support (Fig. 1).



Fig. 1. Tele-guidance system concept

2.2 Remote Caregiver's Terminal

The remote caregiver can either use a workstation, tablet or phablet as terminal. It receives and initiates the VoIP video calls and renders VIP's real-time location coordinates. As VIP can configure many people as his caregiver, the system will help caregivers to mediate time and load of the assistance through availability status info. It will be studied if there is a need for the caregiver to override voice muting by VIP.

The Fig. 2 shows the system's communication and response schematic sequence.

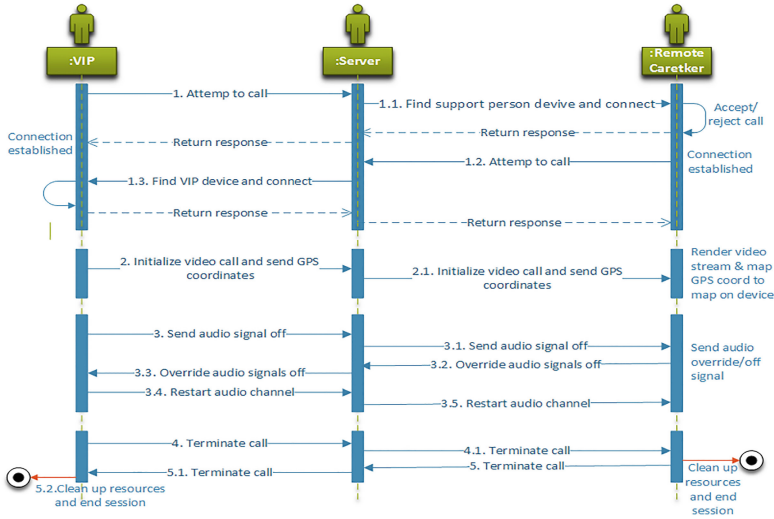


Fig. 2. The communication and response schematic

2.3 Technologies

The technologies chosen for implementation of different features of the proposed tele-guidance system are:

- (1) **Encrypted Communication:** To support privacy between VIP and remote caregiver, encrypted voice, video, and location data communication over the internet is chosen. Linphone API [10] that supports ZRTP protocol will be used to implement communication over the internet functionality [11].
- (2) **Network Connectivity:** Wi-Fi or GSM based internet connection will be used for making VOIP calls and sending real time GPS coordinates of VIP.

3 Usability Testing

The usability testing will be conducted with real blind and VIP in three countries i.e. Finland, Pakistan, and Sweden as part of the ongoing qualitative study by the project [12].

Usability testing by VIP:

- **1st phase:** VIP initiated tele-guidance session and followed voice commands remote caregiver to navigate.
- **2nd phase:** VIP followed tactile guidance by remote caregiver to navigate.
- **3rd phase:** User muted the voice.

Usability testing by remote caregiver:

- **1st phase:** The remote caregiver received a tele-guidance VoIP video call from the VIP and guided him through voice commands.

- **2nd phase:** The remote caregiver guided VIP through tactile commands to navigate.
- **3rd phase:** Remote caregiver gets indication voice about channel muting.
- **Test phase:** Remote caregiver overrides voice muting by VIP.

4 Study for Acceptance of Technological Navigation Assistance Aids by VIP

This study uses an extended version of Unified Theory of Acceptance and Use of Technology (UTAUT2). This model can be used by organizations to gain knowledge on improving the design and marketing of their consumer product [13]. UTAUT2 questionnaire was altered paying attention to the special needs of VIP [14] [Appendix A]. The UTAUT2 constructs are performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV) and habit (HA). Questionnaire includes background questions (BG) and original UTAUT questions from constructs of anxiety (ANX) and attitude (ATT) [15]. Also few questions about special assistive technology themed (SPE) and user's previous experience (PEX) were included in the questionnaire. The questionnaire is intended for both general acceptance study about navigation assistance for VIP and for finding out acceptance issues affecting tele-guidance technologies. During analysis of collected data after earlier reported study [14], it was felt that questionnaires should be extended with users' previous experience specifically about general technological assistance, navigational technological assistance. The qualitative analysis was conducted paying attention on tele-guidance issues and user needs. Those figured out issues were sought by added question about special assistive technology (SPE), user's previous experience (PEX) and routines (RO).

4.1 Preliminary Results of Acceptance Study

19 VIP and blind are interviewed (10 female, 9 male, aged 21–82) in Oulu region in Finland. Our study supports earlier mentioned fact that no single ETA has been widely accepted by the VIP and blind people. None of the sample group used ETAs, and in fact had never even tried those apart from occasional GPS support. It seems that there may be too little information available on ETAs.

9 of the sample group didn't know enough on available tools, 9 perceived that they do have enough information on available tools. 10 participants did like the idea of sending their location information to person(s) close to them. 5 did object this matter. 12 wanted to select themselves the moments when they are being located. 1 participant would have given permission to location data when needed when support person would have been the spouse. If presented an option of new kind of assistance device, 14 of the participants were willing to alter their daily routines, and 13 were willing to use own money on those devices. Nearly all 19 participants were willing to try to learn to use new kind of assistance method.

An accompanying qualitative study addresses the caregivers' needs and acceptance of navigational caretaking tools and services [16].

5 Future Research

Future research will focus on experiments in different outdoor environments and development of efficient navigation training methods for VIP and remote caregivers. The focus will be on how to address and negotiate the situation if remote connection is lost, reduction mechanism of communication delay, and if some miscommunication or non-availability occurs between the VIP traveler and remote caregiver.

6 Conclusion

In this article, a tele-guidance navigation system for VIP in was presented. The approach of the system is based on the idea that a VIP/blind pedestrian can be assisted by spoken instructions from a remote caregiver who receives a video stream from a camera carried by the VIP. The scenarios for the usability testing of overall system for both VIP and remote caregiver to evaluate the usability were presented. A qualitative study to investigate attitude of VIP and blind persons towards navigation assistance tools was also presented.

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Appendix: A

The Questionnaire with UTAUT Constructs		
Serial #	Construct	Questions
1	BG	Age
2	BG	Gender
3	BG	Did you acquire visual impairment with birth or did you lost vision? How long ago?
4	BG	What is your visual acuity?
5	SP	Do you have a support person(s) whom you can contact when you need help? Which hours available?
6	PEX, TA	Do you use smartphone or any other mobile device? What brand? Which apps?
7	PEX	Do you use white cane? When/why did you start using it?
8	PEX, TA	What other assistance tools do you use?
9	PEX, RO, IP	In what situations do you use navigation assistance?

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The Questionnaire with UTAUT Constructs		
Serial #	Construct	Questions
10	PEx	Have you used navigation assistance tools previously? Why did you quit?
Statements		
11	HM	Navigation assistance makes going outdoors more pleasant
12	HM	I like using navigation assistance
13	PV	Navigation assistance tools are reasonably priced
14	HA	Using navigation assistance has become a habit to me
15	PE	I need navigation assistance every time I go outdoors
16	PE	In my opinion navigation assistance is useful when I am outdoors
17	PE	Navigation assistance increases the speed of doing chores
18	PE	If I use navigation assistance, I will increase my chances to get where I want
19	EE	I find navigation assistance tools easy to use
20	EE	Learning to use navigation assistance tools is easy for me
21	SI	People, who are important to me, think that I should use navigation assistance
22	IP	I find it annoying when surrounding people notice I am visually impaired
23	SI	The society has been supportive in the use of assistive
24	SI	Instructors or medical staff have been supportive in the use of assistive
25	FC	My knowledge of using navigation assistance is sufficient
26	FC	If I have problem navigation assistance, I know from who I ask help
27	ANX	I feel nervous using navigation assistance
28	ANX	Navigation assistance is somewhat intimidating
29	ATT	Using navigation assistance is a good idea
30	ATT	Navigation assistance makes me feel safe
31	PV	I am willing to spend money in order to buy new navigation assistance
32	PV, RO	I am willing to spend my time in order to learn to use new navigation assistance
33	RO	I am willing to change my daily routines, if I receive a new kind of navigation assistance
34	RO	I think that people close to me are willing to change their daily routines, if I receive a new kind of navigation assistance
35	IP, SPE	It is good that people close to me know my location
36	IP, SPE	I would like to select when people close to me know my location

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