Tele-guidance based orientation and mobility system for visually impaired and blind persons

B Chaudary, P Pulli, I Paajala, E Keino

Department of Information Processing Science, University of Oulu,
Penti Kerainen Katu 1 , 90014 Oulu, FINLAND

babar.chaudary@oulu.fi, petri.pulli@oulu.fi, iikka.pajaala@gmail.com, eliud.keino@gmail.com

www.tol.oulu.fi

ABSTRACT

The design and development of tele-assistance services have received great consideration in the domain of healthcare lately. Telecare solutions are seen as a potential means of addressing the future care needs of ageing societies. With the growing proportion of dependent people (ageing, disabled users), tele-assistance and tele-monitoring platforms will play a significant role to provide efficient and less-costly remote care and support. It will allow aged and disabled persons to maintain their independence and lessen the burden and cost of caregiving. In the case of visually impaired persons (VIP) and blind persons, guide dogs and white canes provide them a fair degree of independence. However, those are very limited in guiding the user towards a specific desired location, especially in an unknown environment. The assistance of other people presents a feasible solution, though it does not improve the idea of autonomous guidance and privacy. 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 her. The assistive tools have reportedly acceptance issues by VIP. The paper also presents a qualitative study using a modified version of UTAUT-2 (Unified Theory of Acceptance and Use of Technology) to find out causes for acceptance issues in navigation tools for visually impaired. Another goal of the study was to validate the UTAUT2-model as suitable for researching acceptance issues of navigation assistance tools of VIP.

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. It is estimated that there are 285 million VIP in the world, 39 million of these being completely blind. 82% of the blind people are aged 50 years or more. The growing number of elderly people results in increased problems caused by the old age such are chronic eye diseases (WHO Global Data on Visual Impairments, 2010). 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 miniaturization, the devices that are termed as Electronic Travel Aids (ETA) are very slowly fighting their ways into the community of VIP. In fact, no single ETA has been widely accepted by the VIP and blind as a useful aid (Bourbakis, 2008).

ETA is the general term encompassing a large class of assistive devices aiding the VIP in mobility. There has been a long lasting research record on ETAs helping the blind in obstacle avoidance and navigation. 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 for the blind (Bourbakis, 2008).

The following is a functional, rather than technological classification of these assistive devices (Strumillo, 2012):

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

The first two classes of aids are personal (wearable) devices that scan the environment in personal and near spaces. These devices have the task to assist blind people to intercept obstacles on their path. On the other hand, the third group of aids are the 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. RFIDs, 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 (Strumillo, 2012). The underpinning idea of this class of ETAs is that a blind pedestrian is guided by spoken instructions from a remote caregiver who remotely receives a video stream from a camera carried by the blind user. The remote vision facility permits the remote sighted guide to navigate the visually impaired user of the system in the immediate travel environment i.e. micro-navigation; e.g. the assistance in the avoidance of obstacles and other hazards in the path of travel, while the GPS and GIS data facilitates the navigation through the environment on a large scale i.e. macro-navigation.

The first reported system for remote guidance of the blind, was the system developed at the Brunel University, UK (Garaj el al., 2003). Three ICT technologies were combined to offer the tele-assistance functionality; namely, GPS (Global Positioning System), GIS (Geographic Information System) and video/voice transmission over the 3G mobile network. The system comprises of two units. The backpack mobile unit equipped with a portable camera and an audio headset that was carried by the blind user and a stationary PC based unit for remote caregiver. (Bujacz et al., 2008A) developed a tele-assistance system 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 (Baranski, Polanczyk and Strumillo, 2010), the authors developed a remote guidance system where the visually impaired 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. Using audio communication, the operator navigated the VIP towards a desired location and warned him about possible obstacles. Similar tele-assistance systems were developed by (Hunaiti, Garaj and Balachandran, 2006), (Bujacz et al., 2008B), (Koley and Mishra, 2012), for visually impaired pedestrians. In Japan, API AI Co (API AI Co, 2016) and BlindMaps (BlindMaps.org, 2016) are developing technology and prototypes for making the white cane a connected device which can act as an interface to the urban environment and to the user's smartphone, has very many ideas that have potential to complement such system.

The former tele-guidance systems either used bulky back packs or special purpose mobile terminals to be carried by the VIP. This fact effected 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-assistance based orientation and mobility system enables VIP to initiate a rich tele-guidance session with a remote caregiver when they need remote assistance during navigation. The remote caregiver can assist VIP remotely using voice commands and/or haptics/vibration based interfaces by using field of view of VIP and complementing data on his terminal.

2. SYSTEM DESCRIPTION

The proposed tele-guidance system comprises of two terminals, VIP's terminal and remote caregiver's terminal, Figure 1.

2.1 VIP's Terminal

The VIP's terminal has 4 components:

- *Smart phone.* It provides connectivity with the remote caregiver's terminal through Wi-Fi or GSM based internet connection. The video, voice, and location coordinates of VIP using smart phone GPS are transmitted over the internet to remote caregiver.
- *Bluetooth webcam.* A Bluetooth webcam that is connected to smart phone is mounted on the chest of the VIP. It will be used to send real time video of the field of view of the VIP to remote caregiver.
- *Bluetooth headset (Bluetooth earpiece, speaker).* The Bluetooth head set (mic and speaker) is used for voice communication between VIP and caregiver.
- *Smart Cane (Braille Cell, Directional Vibrators, Bluetooth Interface).* The smart cane contains directional vibrators for navigation assistance, tactile braille cell, and Bluetooth interface to connect/control it with the smart phone.

It will enable VIP to initiate a need based rich tele-guidance (audiovisual) assistance session with a remote caregiver. The remote caregiver will receive the audio call and location coordinates of the VIP when the remote assistance session is initiated. If signals' quality is good, the caregiver will initialize the video channel to start video feed transmitted from from VIP. The remote caregiver will now start providing on site assistance to VIP remotely through voice commands or haptics/vibration interfaces of smart cane accordingly. During the remote tele-guidance session, VIP will be able to mute the voice channel anytime while video still on if she wants to make sense of the environment by listening surrounding sounds. The remote caregiver will get a notification about it.

The smart cane is being developed as part of this project to provide caregiver with extra modalities to assist VIP remotely. Especially as studies suggest, engaging VIP hearing during navigation is not recommended. The smart cane will be connected to the smart phone and will allow remote caregiver to assist VIP through vibration and haptics interfaces. This component will potentially extend the functionality of conventional voice-based tele-guidance ONS systems as presented before.

The VIP will be able to configure more than one person as his caregiver e.g. mother, father, relative or some professional or volunteer caregiver. If either of those higher in preferences is not available, the tele-guidance assistance request will be automatically transferred to the one available. All configured caregiver will receive an SMS alert on their phone if neither of them is available at any time when VIP calls for assistance.

Figure 1. *Tele-guidance system concept.*

2.2 Remote Caregiver's Terminal

The remote caregiver can either use a desktop workstation OR a tablet or phablet (big screen smart phone) as his terminal. It will transmit two-ways voice, render map data of the VIP's location coordinates, and display the real-time video of VIP's field of view. The live video stream will be used to assist VIP in micro navigation i.e. travelling in immediate path and avoiding obstacles. VIP's real time map data will enable the remote caregiver provide assistance in macro navigation i.e. in far field navigation to travel from one place to other remote place. The tele-guidance will be provided through spoken instructions or haptics and vibration based interfaces accordingly

The availability status (being online) of all configured caregivers of a VIP will be available to all available caregivers. This will facilitate them to mediate load of the guidance. As VIP will be able to mute caregiver's voice anytime during tele-guidance, it will be studied if there is a need for the remote caregiver to override muting if necessary e.g. in a possible hazardous situation ahead.

2.3 Technologies

The technologies selected to implement different features of the proposed tele-guidance system are:

- *Communication.* Wi-Fi or GSM based internet connection will be used for establishing voice, video call and transmitting GPS coordinates of VIP to remote caregiver.
- *Privacy.* To support privacy between VIP and remote caregiver, encrypted voice, video, and location data communication over the internet is chosen. Linphone API (Linphone, 2016) will be used to implement this functionality. Linphone is a free voice over IP (VoIP) service and SIP client. It supports ZRTP (Answers to your ZRTP Questions, 2016) for end-to-end encrypted voice and video communication.

- *ZRTP (composed of Z and Real-time Transport Protocol).* ZRTP is a cryptographic key-agreement protocol to negotiate the keys for encryption between two end points in a Voice over Internet Protocol (VoIP) phone telephony call based on the Real-time Transport Protocol. It uses Diffie–Hellman key exchange and the Secure Real-time Transport Protocol (SRTP) for encryption. ZRTP stands for "Zimmermann Real-time Transport Protocol" and was developed by Silent Circle's own, Phil Zimmermann.

ZRTP is key exchange protocol designed to enable VoIP devices to agree keys for encrypting media streams (voice or video) using SRTP. ZRTP is defined in an Internet draft http://tools.ietf.org/html/draft-zimmermann-avt-zrtp. The authors of ZRTP describe it as "Media Path Key Agreement for Secure RTP". This means that the ZRTP end points use the media stream rather than the signaling stream to establish the SRTP encryption keys. Many other key exchange protocols use the signaling stream (for example SIP or H.323) for media key exchange. The disadvantage of this approach is that the key exchange is visible to any intermediate device that processes the signaling stream.

ZRTP's use of the media path for key agreement ensures that media keys are agreed directly between the caller and call recipient and those keys are not visible to any intermediate signaling device. This makes ZRTP an ideal choice for use on networks where signaling is processed by intermediate devices and where it is important to ensure call confidentiality (http://www.voip-info.org/wiki/view/ZRTP).

Figure 2 shows the communication and response schematic sequence of the proposed tele-guidance system. As shown in the figure, there are three interaction objects i.e. VIP, Server, and Remote Caregiver that describe how and in what order objects/components of system work together and how tasks are moved between them.

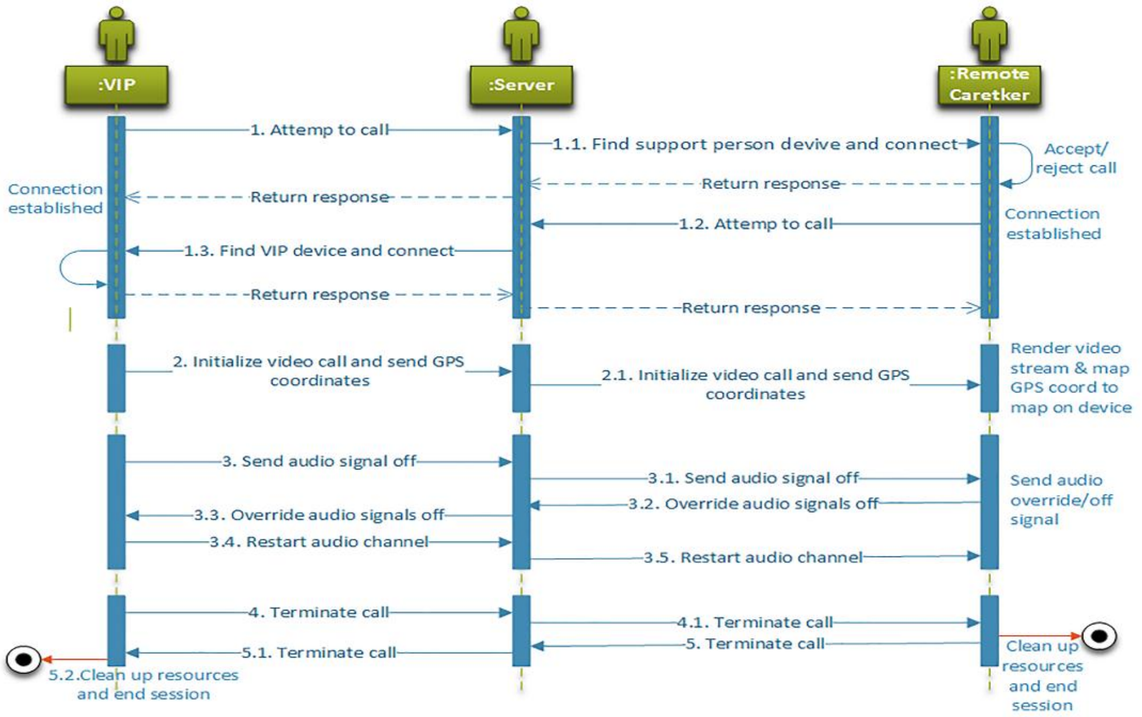

Figure 2. *The communication and response schematic*

3. USABILITY TESTING

The main objective of conducting usability experiments is to remove problematic issues from assisting users to navigate them through proposed tele-guidance system and identify the flaws that have been hidden through the development process from developer's point of view. Analyzing tasks of usability test facilitates designing system's concept more accurately. In order to organize usability testing before conducting it, a set of assumptions should be predefined, and then assumption should be evaluated after the usability testing. There should be 4 to 6 participants in usability testing to rely on results; a final report should outline findings and provide developers with recommendations to redesign the system. (Donahue, Weinschenk and Nowicki, 1999, Nielsen, 1994, Jeng, 2005, Sauro and Kindlund, 2005).

3.1 Test scenarios

Test subjects in all experiments will be real VIP; fully blind or near blind. In future, we are potentially interested to support deaf-blind persons too as well though it requires further modalities to be added to the tele-guidance system.

Test scenarios for VIP:

- *1st phase:* VIP user initiated a tele-guidance session and followed voice and haptics/vibrations based instructions of the remote caregiver for navigation successfully.
- *2nd phase:* User muted the voice.

Test scenarios for remote caregiver:

- *1st phase:* The remote caregiver received a tele-guidance call from the VIP and guided her through voice and haptics/vibration based instructions to navigate successfully.
- *2nd phase:* Remote caregiver gets indication that VIP muted the voice channel.
- *Test case:* Remote caregiver overrides the muted voice channel.

3.2 Usability matrices

The specified usability metrics will be used to evaluate the results of all tests. The metrics will define all experiment settings for a given test e.g. detail of paths, hazards on the way, muting of voice commands from remote caregiver, and success/fail condition. The results will help to investigate effectiveness, efficacy, satisfaction, and learnability of the system. These categories will be measured by the percent they complete the task, how long it takes to complete the tasks, ratios of success to failure to complete the tasks, time spent on errors, the number of errors, rating scale of satisfactions, number of times user seems frustrated, etc. Additional observations of the users give designers insight on navigation difficulties, controls, conceptual models, etc. The ultimate goal of analyzing these metrics is to find/create a prototype design that users like and use to successfully perform given tasks (Wickens, 1992) (Kuniavsky, 2003).

4. ATTITUDE OF VIP AND BLIND PERSONS TOWARDS NAVIGATION ASSISTANCE

As previous studies have indicated, assistive tools have acceptance issues by VIP. The thresholds for accepting and starting the use of assistive tools have number of potential reasons related to either assistive tool or user (Nordqvist, 2003, Ravneberg, 2009, Salminen, 2003). Tool-related reasons include accessibility, usability, safety, and appearance of the tool (Wickens, 1992, Nordqvist, 2003). Whereas user-related reasons include user’s previous experiences and attitude for technology, technological prowess and perceived need for the tool. Also if the assistive tool marks the user as different may cause rejection (Salminen, 2003, Söderström & Ytterhus, 2010).

This study uses an extended version of Unified Theory of Acceptance and Use of Technology (UTAUT2), which is designed for consumer acceptance context. This model can be used by organizations to gain knowledge on improving the design and marketing of their consumer product (Venkatesh, Morris, Davis and Davis, 2003). The question set was modified to suit the VIP [APPENDIX A]. The UTAUT2 model constructs are performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), hedonic motivation (HM), price value (PV) and habit (HA) (Venkatesh, Morris, Davis and Davis, 2003). The constructs are moderated also by age and gender (Venkatesh, Morris, Davis and Davis, 2003) which are asked by background questions (BG). Because the questionnaire is about assistive tools and for special group, we felt that some original UTAUT (Venkatesh, Thong, and Xu, 2012) questions should be included, especially from group of anxiety (ANX) and attitude (ATT), which had been dropped from the UTAUT2 model.

In addition, groups of questions not related to technology acceptance were included. The questions suit especially for tele-guidance tool design. These include questions assessing the potential for specific assistive technologies for the purposes of developing prototypes (SPE). The prototypes include tele-guidance system with location finding functionality. Also questions on willingness to adapt new technologies (TA) of visually impaired and previous experience (PEx) of using navigation assistance, on support persons (SP) availability, habits, and willingness to change routines or practices (RO), and whether there are independency and privacy issues (IP), were included.

The questionnaire is divided into two parts, the first being a semi-structured interview set of 10 premade questions and few possible follow-up questions (question numbers 1-10), and the second part consists of 26 statements which are to be answered with 5 point Likert scale (question numbers 11-36).

4.1 Details of the study

4.1.1 Participants and findings based on background questions. The number of participants was 19. Their ages varied (19-82 years) and they were in all planned age groups (i.e. 18-39, 40-64, 65-above) and sexes (Male and Female). Within the youngest and oldest age group, women seemed to be more interested in participating in this study while men dominate the middle age, Figure 3. The level of vision varied from total blindness to low vision. Figure 4 illustrates that there are more VIP who have lost their vision gradually as been born VIP. There is not great difference between sexes.

Approx. half of the participants were smartphone users. The eldest age group was using least of navigation assistance. Figure 5 shows how the different age groups own and use mobile devices. The “yes” circle demonstrates the percentages of participants using mobile device by each age group. And “no” circle demonstrates the exactly the same on not using. The youngest age group is most keen on using mobile devices in contras of the eldest who are not that interested using them.

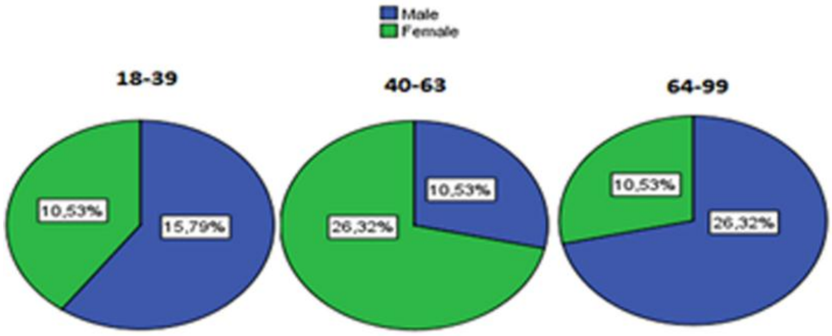

Figure 3. *Percentage of male-female participants by age group*

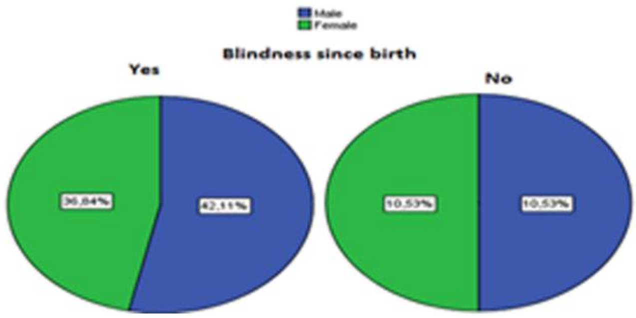

Figure 4. *Percentage of male-female participant’s blindness since birth*

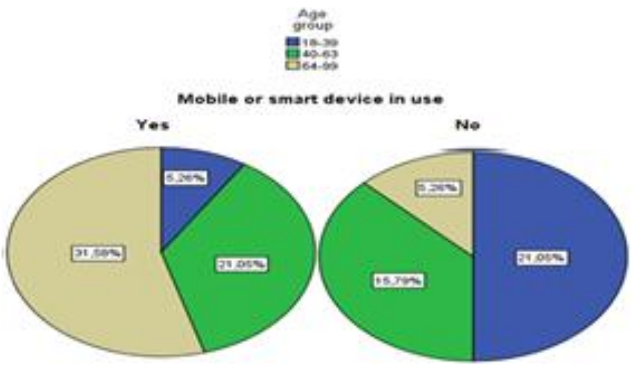

Figure 5. *Percentage of mobile or smart device users by different age group.*

4.1.2 Analysis methods. Mixed methods was used as research method for this study. Both numeric and narrative data were collected. Quantitative data was analyzed first, that provided a good background for qualitative analysis. Though as number of participants was low i.e. 19, the statistical results are directive. The statistical analysis was done through SPSS program. The data was analyzed with regression test, variance tests, and non-parametric tests. The statistical tests were done with 3 background variables: gender, age, and age group.

Regression analysis is meant to find out linear dependency of two variables. Variables included were age, gender, age group and UTAUT2-model constructs. Cross-tabulation is used to find connection between two variables. The connections were investigated between attitude and gender, age or age group. Variance analysis is conducted on the material. Factor analysis is meant for describing same phenomenon on fewer dimensions: In other words, to compress the information. This would make the interpretation of the factors easier.

The qualitative data amount was not huge as the questionnaire served mainly the quantitative aspect of the research. The qualitative analysis was two-phased. In the first phase the questions were sorted on how they may give answers to the selected topics. For example for finding out "Technological adaption" questions 6, 8, 31, 32, 35 and 36 were picked. The second phase was used to check whether any data were missing. A simple keyword list was considered at first but the qualitative data material amount was small so the list was abandoned. Each interview was transcribed and those parts containing answers to different categories were easily found even without the keyword list.

4.1.3 Analysis and discussion. The data set collected through modified UTAUT2 – model questionnaire was used to measure if UTAUT2 acceptance model is usable when assistive technology for VIP is studied. The questionnaire is meant to measure UTAUT2-model variables. If the questions are created in a way that they measure each variable, then factors can be derived from the answers. Factors can be then analyzed further. If the internal consistency is high among the answers, the model is suitable for this kind of study. When the internal consistency is low, it is a sign that the questions don't measure the phenomenon at hand (in this case a UTAUT2-model variables).

The UTAUT2-model variables are factored by Varimax-Rotation method. The internal consistency has been checked for each variable. Further tests have been made for each variable included in a factor and which support the UTAUT2 model. Factors are scrutinized by factor loadings, commonalities and Cronbach's alpha.

Figure 6 shows how UTAUT2 -model is usable for studying acceptance issues by VIP. Middle row presents the UTAUT2 constructs and bottom row presents the questions which measure these constructs. UTAUT2-model variable "Social Influence" is measured by three questions. The analyzed results indicate that these questions do not measure the variable, because the three questions and answers do not load on the same factors and their internal consistency is low: The Cronbach's alpha is negative (-0.31). This means that this data do not support that UTAUT2-model variable. The same goes with construct "Facilitating Conditions" with low Cronbach's alpha (0.11) showing there is no internal consistency between the variables. Other variables than the mentioned two support the UTAUT2-model when scrutinizing Cronbach's alpha value.

4.1.4 Conclusion. As a result, it seems that the model is usable for this kind of research. Nevertheless, some questions don't support or measure given variable. Some questions should be considered and tested again. Consideration here may mean that the Finnish translation of the questions could be adjusted. Or maybe, in retrospect, the removing few of the UTAUT2 questionnaire statements aside could have been an error. This was done to shorten the interview duration. Also some of the UTAUT2 questions were hard to modify to suit for this special purpose, the assistive navigation tools for VIP. As a conclusion for quantitative analysis, it can be said that men and women react differently for technological assistance tools. Women do have more negative attitudes towards technology than men, Figure 7.

5. CONCLUSIONS

In this article, a tele-guidance based navigation assistance system to assist VIP in navigation was presented. The approach of the system is based on the idea that a blind pedestrian can be assisted by spoken instructions from a remote caregiver who receives a video stream from a camera carried by the visually impaired user. Different usability testing phases of the system were described. The scenarios for the testing of overall system for both VIP and remote caregiver to evaluate the usability factors of the system in each of its testing phases were specified. We expect that participants could complete their tasks with the help of the proposed system. Task accomplishment could fulfil expected efficacy and effectiveness of system. Results of the usability test will provide with actionable suggestion to increase usability of the proposed tele-guidance system.

A qualitative study using a modified questionnaire based on Unified Theory of Acceptance and use of Technology (UTAUT) to study attitudes of VIP towards navigation tools (technological & non- technological) was also reported in the article. As a conclusion for the qualitative study, it can be said that VIP in general have an interest towards technology and new kind of assistive tools. Unfortunately the participants have not found much navigation assistance devices suitable to their tastes. This means that the VIP should be taken into design process. Technology may increase the acceptance in the future, but so far it has not been the case. Furthermore, every-day mobile technology is already becoming common among VIP's and applications for those devices can be designed. Advantages of mobile applications include non-stigmatization and affordability. Many of the VIP are used to white canes, and also for the cane's extra function as the signal cane. Therefore creating light weight, low-price extra-functions for the cane is a good idea. Especially there is a need to encourage elderly VIP to acquire and use assistive tools.

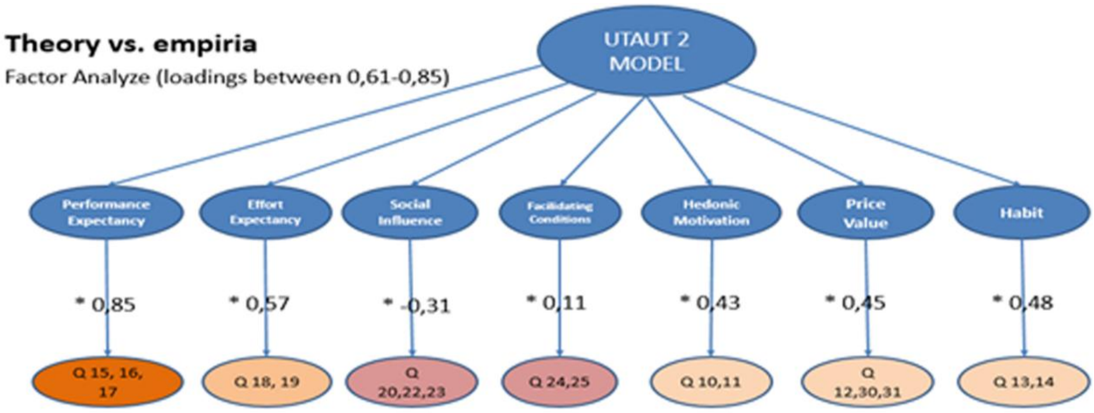

Figure 6. *The analyzed UTAUT2 constructs.*

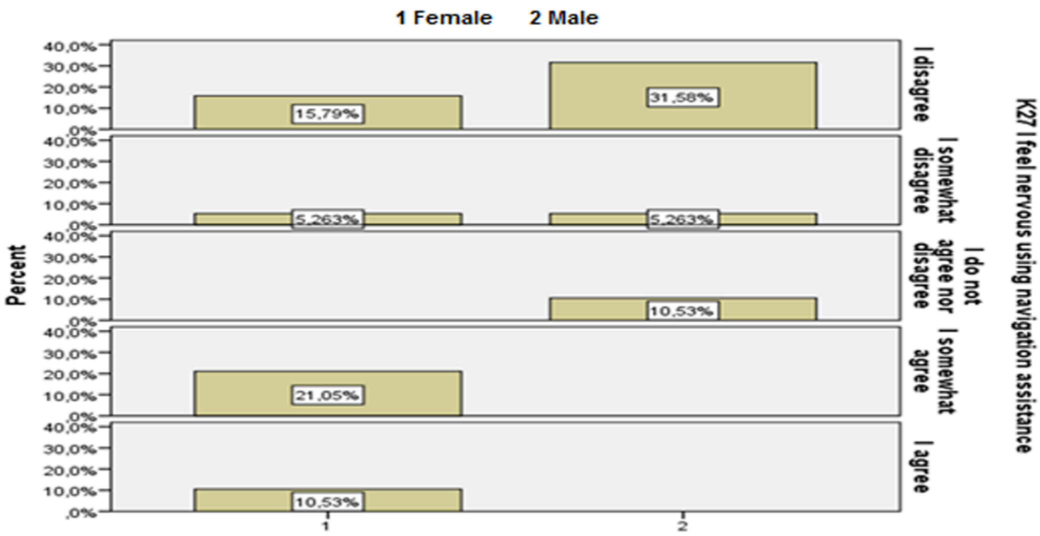

Figure 7. *Nervousness towards navigation assistance by gender*.

Acknowledgements: This paper has been written as part of the ASTS (Assisted Living for Senior Citizens) Project funded by Academy of Finland and Japan Science technology Agency (JST).

7. REFERENCES

Answers to your ZRTP Questions (2016), https://silentcircle.com/faq-zrtp

API AI Co (2016), http://www.api-kk.com/denshi-hakujo/

BlindMaps.org (2016), http://www.blindmaps.org/prototypes/

Baranski, P, Polanczyk, M., & Strumillo, P. (2010, July). A remote guidance system for the blind. In e-Health Networking Applications and Services (Healthcom), 2010 12th IEEE International Conference on (pp. 386-390). IEEE.

Bujacz, M, Baranski, P., Moranski, M., Strumillo, P., & Materka, A. (2008A, September). Remote mobility and navigation aid for the visually disabled. In Proc. 7th Intl Conf. on Disability, Virtual Reality and Assoc. Technologies with Art ArtAbilitation, in PM Sharkey, P. Lopesdos-Santos, PL Weiss & AL Brooks (Eds.) (pp. 263-270).

Bujacz, M, Baranski, P., Moranski, M., Strumillo, P., & Materka, A. (2008B, May). Remote guidance for the blind—A proposed teleassistance system and navigation trials. In 2008 Conference on Human System Interactions (pp. 888-892). IEEE.

Bourbakis, N. (2008). Sensing surrounding 3-D space for navigation of the blind. IEEE Engineering in Medicine and Biology Magazine, 27(1), 49-55.

Donahue, G. M., Weinschenk, S., & Nowicki, J. (1999). Usability is good business. *Compuware Corp.*, *julio*.

Garaj, V, Jirawimut, R., Ptasinski, P., Cecelja, F., & Balachandran, W. (2003). A system for remote sighted guidance of visually impaired pedestrians. British Journal of Visual Impairment, 21(2), 55-63.

Hunaiti, Z., Garaj, V., & Balachandran, W. (2006). A remote vision guidance system for visually impaired pedestrians. Journal of Navigation, 59(03), 497-504.

Jeng, J. (2005). Usability assessment of academic digital libraries: effectiveness, efficiency, satisfaction, and learnability. Libri, 55(2-3), 96-121.

Kuniavsky, M. (2003). Observing the user experience: a practitioner’s guide to user research. Morgan Kaufmann.

Linphone (2016), http://www.linphone.org/

Mishra, R., & Koley, S. (2012). Voice Operated Outdoor Navigation System For Visually Impaired Persons. International Journal of Engineering and Technology, 3(2), l53-157.

Nielsen, J. (1994, April). Usability inspection methods. In Conference companion on Human factors in computing systems (pp. 413-414). ACM.

Nordqvist, B. (2003). Nähdä. In A-L. Salminen (Eds.), *Apuvälinekirja* (94-110). Helsinki: Kehitysvammaliitto, Oppimateriaalikeskus.

Ravneberg, B. (2009). Identity politics by design: users, markets and public service provision for assistive technology in Norway. Scandinavian Journal of Disability Research vol. 11, No. 2, 101-115

Sauro, J., & Kindlund, E. (2005, April). A method to standardize usability metrics into a single score. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 401-409). ACM.

Salminen, A-L. (2003). Apuväline toimintaa edistämässä. In A-L. Salminen (Eds.), *Apuvälinekirja* (18-32). Helsinki: Kehitysvammaliitto, Oppimateriaalikeskus.

Söderström, S. & Ytterhus, B. (2010). The use and non-use of assistive technologies from the world of information and communication technology by visually impaired young people: a walk on the tightrope of peer inclusion. Disability & Society vol. 25, issue 3. pp. 303-315

Strumillo, P. (2012). Electronic systems aiding spatial orientation and mobility of the visually impaired. In *Human–Computer Systems Interaction: Backgrounds and Applications 2* (pp. 373-386). Springer Berlin Heidelberg.

Venkatesh, V., Morris, M.G., Davis, G.B. & Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly vol 27, No. 3, pp. 425-478.

Venkatesh, V., Thong, J.Y.L., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. MIS Quarterly vol 36. No 1. pp. 157-178.

Wickens, C. D., Hollands, J. G., Banbury, S., & Parasuraman, R. (2015). *Engineering psychology & human performance*. Psychology Press.

WHO Global Data on Visual Impairments (2010), http://www.who.int/blindness/ GLOBALDATAFINALforweb.pdf?ua=1

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	Have you used any other navigation assistance? Did you stop using it? Why?
9	PEx, RO, IP	In what situations do you use navigation assistance?
10		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	33	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.