Requirements of a Mobile Application Design Model for Visually Impaired People

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Abstract

Visually Impaired People (VIP) is using mobile applications to complete their daily tasks. This ratio of using mobile applications is growing very fastly. Many accessibility features for VIP from these mobile applications are provided, but there are many fundamental problems still create difficulties for VIP. In case when touchscreen mobile applications are used by VIP. The main problem is that VIP faces problems due to lacking facilities and requirements according to their needs. In this paper, the basic requirements of mobile application design for VIP were explored with the help of re-examining the current design guidelines of mobile phone applications. In this paper total, 8 VIP has participated. For smartphones, mobile application design user experience and accessibility requirements were collected. In order to check the requirements and accessibility of a mobile application, a five-points Likert scale is used. In the result of re-examining on current design guideline, there was described new requirements of mobile application design with the help of participants. These requirements will enhance the user experience of VIP to access mobile phone applications.

Keywords: Visually Impaired People, Mobile Application, Requirements of mobile application design ,Visual Impairment

1. Introduction

Mobile devices like smartphones, smartwatches and tablet computers are very common nowadays[1]. Touchscreen mobile devices provide a direct input method that is appropriate and easy to use for mobile devices.VIP use these smart mobile devices to fulfill their tasks like call making, taking photos, reading a text, enlarge the text and music listening[2][3][4]. Touchscreen mobile phones are preferably used to do all these tasks. In order to provide comfort for VIP, these smartphones are providing various accessibility features like text enlargement, screen color contrast, text to speech and voice input. In the presence of these features VIP still, face a number of problems while using mobile applications. Rodriguez-Sanchez et al. [5] described that even there are

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many types of research on usability and accessibility and many VIP faces the problems due to lacking facilities and requirements according to their needs.

It is compulsory to build-up a reasonable design model of touchscreen-based mobile application, because of VIP is using these smartphones in a progressive ratio. In the case of VIP, it is necessary that User-centered design should be applicable on all mobile applications.

The latest report by the World Health Organization [6] on dated 18 Oct 2018, there were about 1.3 billion people have lived with some visual impairment. This is a large portion of the total population but this portion remains cut off from new mobile development and research design technology. There is proof that VIP [7][8] faced many problems while using mobile applications. There were many types of research that have explored the wishes and requirements of VIP with respect to the requirements of mobile phone applications. In this exploration, they found the multi-functional abilities that are not available in old mobile phone applications. From practical research especially on the accessibility of mobile phone user interface design guidelines for VIP, there is no extensive contract. For VIP, global designing access should be allowed in mobile application designing.

Touchscreen and traditional both types of mobile phones are used by VIP. The only difference is a way of using mobile applications is different from fully sighted users. The result could be increased usability and accessibility of mobile phone applications if mobile phone application developers are thought about the requirements of VIP at the time of requirement gathering and designing [9].In short, there is a need for promoting the research for the accessibility of mobile phone applications for VIP. Expectations and requirements about the accessibility of mobile applications should be focused by researchers with additional performance. The expectations of VIP's concerning with mobile phone applications is investigated in this paper. In order to increase the effectiveness and accessibility of mobile applications for VIP, these results should be considered when designing the new mobile phone applications.

In this paper, the accessibility coefficient factor was investigated regarding the requirements of the mobile application design model for VIP. This investigation is fulfilled by a five-point Likert scale on collecting user requirements with the help of expert visually impaired mobile application users.

The remaining part of this paper is organized as follows: Section 2 describes the background & literature review. Section 3 describes the methodology of the experiment. Results & discussion are discussed in Section 4. Requirements of mobile application design model to enhance the accessibility of VIP in Section 5. The conclusion and feature works are described in Section 6.

2. Background & Literature Review

There is an increase in the accessibility of mobile phone applications in order to provide better facilities for the maximum number of VIP. The software and hardware's operational suitability is communicating with a mobile application's design[10][11][9][12][13]. With the help of web usage, software developers proceed to develope assistive mobile applications[14]. In order to improve the accessibility of web sites, design guidelines have described by the World Wide Web (WWW)[15]. Similarly, for better accessibility in terms of accessibility of web content, a large number of accessibility guidelines have become visible to help software developing and web content [16]. There are many types of research that have concentrate on the requirements of smart devices due to a growing population of mobile phones, like Personal Digital Assistant (PDA) and smartphones. For VIP there are many assistive mobile applications that are accessible when they use mobile applications[17].

In order to improve the navigation performance for VIP, Guerreiro at al. [10] evaluated the NavTouch and NavTap input methods for smart mobile phones. They found out that because of gestures are very smooth functioning inactivity in NavTouch hence it is more effective than NavTap. Oliveira at al. [21] described four types of keyboards that are useful for VIP on mobile phone applications. These keyboards are QWERTY the standard one, NavTouch, MultiType, and Braille-Type. Each keyboard had its own pros and cons according to their suggested results. There may be a necessity of memory, awareness, and spatial facilities for VIP in Smart device's keyboards.

The generation of new responsive gestures[22], preference and performance of gestures[23], one hand gesture and two hand gesture's usability difference[14]. For VIP, the researchers in Human-Computer Interaction (HCI) have paid attention to all these gestures. The selected functions performed by VIP may be affected due to the usage of buttons on smartphones. Responsive smartphone's buttons developed by Yfantidis and Evreinov [24], the functionality of this button is it generates the input from a single finger in eight different directions from any point. Kane at al. [20] differentiates the working behavior of VIP on smart mobile devices. They observed that VIP did not take much interest in button-based touch but choose an audio-based method.

There is a lower success experience of VIP with smart mobile phones in comparison to fully sighted people. The support level requires for VIP to fulfill the tasks is very high. In order to investigate capability and user preference of VIP, these smartphones have been used as a primary investigational tool. Kane at al. [19] recommended that many functions are identified for VIP, which increases their accessibility on their mobile phones. These recommendations include screen contrast, magnification of screen, screen readers, button size, and voice inputs. In order to recall information and to make a call most of the VIP(around a total of 18%) were found to use auditory gestures [25]. There is definitely a need for the development of mobile application design for VIP.

In previous researches, only traditional mobile phones have been focused instead of smart mobile phones. On the other hand at this time the preparation of smart mobile

phones and user interfaces at its peak. Estimation in the year 2017, that there is almost all the new mobile phone manufacturing is smartphones. The user interfaces of these mobile phones like flat touchscreen, large screen size, soft keyboards, complicated placements of application icons are created many difficulties for VIP to use the mobile application. In order to fulfill the needs and hopes of VIP, it is necessary to modify the accessibility and materialization features of smart mobile phone application design.

In mobile designing especially the software part, many operational buttons are combined with that software part. Due to this method, the production costs less but on the other hand, it also minimizes the chance of touch cue for VIP. The mobile applications can provide some accessible features for VIP with its quick development. Kane at al. [23] insisted that in order to use the mobile application interface VIP still required substitute. Nancy[26] mentioned that in order to search for information and read or receive the news these digital devices and computers have become a primary role. In this context, confirming that VIP can also use these devices for searching and receiving the data.

Although VIP using mobile applications on regularly, they have still difficulties in accessibilities and experience in operating their mobile applications[27]. In addition to this, the VIP wants to access advanced functions. Regardless of the difficulties that are in their operations because of restricted accessibility features. There are many restrictions and challenges even for sighted people like screen size is too small and difficulties in data entry[28]. In this research, aims to enhance and improve the accessibility features of mobile phone applications for VIP.

3. Methodology

In order to develop interactive mobile phone applications, the Human-Computer Interaction (HCI) group have been adopted the User-Centered Design (UCD) approach. This approach is adopted after introduced the UCD by Gould and Lewis[29]. In this approach at every stage of the development, the end-user must be involved. How earlier you involved the end-user in the life cycle, your product will get better in usability and customer satisfaction will be an increase[30].

In this experiment total, 8 VIP participated all participants are male. The average age of all participants was 28.3 years and they all have more than two years of experience using the smartphone-based mobile application(Mean=1.85, SD=0.43). All the participants have limited light sensation and according to the World Health Organization, they all were visually impaired. All the participants have achieved higher than secondary school education from the school of visual impairment.

This research includes a detailed analysis of the present mobile phone application on its accessibility, requirements of VIP, guidelines, and standards. Requirement gathering from the user base on accessibility features. The user requirements are based on accessibility, effectiveness and easy to use. On the bases of these attributes assess the user requirements. A questionnaire is designed using a 5-points Likert scale(1=not

important to 5 = most important). This questionnaire was completed by each participant with the help of a researcher, who collaborated with VIP to complete this questionnaire.

Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
(1)	(2)	(3)	(4)	(5)

5-points Likert scale

In order to calculate the final guidelines, the SPSS tool was used. This tool gave the analysis reliability, analysis of variance and independent test samples. In the selection method of final guidelines only choose those user requirements which have a rating 4 or 5 at least from four participants. It is made sure that all the user requirements are rated by the participants. The user

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{i=1}^{k} \sigma_{y_i}^2}{\sigma_x^2}\right)$$

Cronbach's alpha reliability coefficient formula

k Refers to the number of scale item

$\sigma_{y_i}^2$ Refers to the variance associated with item i

σ_x^2 Refers to variance associated with the observed total scores

requirements than converted into guidelines of a mobile application design model for VIP. Cronbach's alpha reliability coefficient is used to calculate the reliability of user requirements.

4. Results & Discussion

The exploration result of literature is that there are many user requirements are described. But in this paper, we considered only basic requirements that are necessary for VIP. In this result of the questionnaire, there would be decided 19 basic user requirements that show the high-reliability value. These user requirements converted into the basic design guideline of a mobile application for VIP. There is an identification of various features regarding the mobile phone application design that strongly impacts on easy to use, effectiveness, and accessibility. The high rating of VIP the researcher agreed on some of the guidelines definitely followed by the mobile application developers. Many types related to media are also needed to update that would be supported to VIP in exploring the multi menus, making calls, voice activation, and input text notifications.

In order to calculate the reliability of user requirements listed on a five-point Likert scale, Cronbach's alpha reliability coefficient is used. The normal value range of Cronbach's alpha reliability coefficient between 0 and 1. The closer the coefficient is to 1.0, the greater is the internal consistency of the items (variables) in the scale. The results disclose that questions in a questionnaire had highly reliable if their value is of Cronbach's a= 0.839

In order to find the softkeys and icon from the mobile application, the participants have difficulties to access them. It is also clearly shown in Table 1 where the item named "Proper Space and edge of buttons" has Cronbach's alpha reliability value is .692. Participants show much interest in the audio output and inputs like it is clearly shown in Table 1 that Sr# 6,7,12,13,17 are related to voice input and having the high Cronbach's alpha reliability values.

Table 1: Cronbach's alpha reliability coefficient of selected user requirements

Sr #	User Requirements	Cronbach's alpha Reliability
1	Mobile size	.732
2	Home button detectable	.712
3	Scratch safety	.613
4	Proper Space and edge of buttons	.692
5	Fix places of home and power buttons	.797
6	Proper voice error notifications	.823
7	Proper voice notifications for battery power	.831
8	Display screen with proper contrast	.779
9	Voice activation is proper	.887
10	Speed Dailing	.775
11	Cursor blinking on entry	.765
12	Heard of entring Character	.883
13	Touched Item also heard	.893

14	Easy on/off on sound feedback	.745
15	Adjustable volume during a call	.734
16	Self error correction	.732
17	Notification of task completion	.897
18	No grouping of a menu item	.764
19	The main menu on the left corner	.701

The user accessibility factor is shown in Table 1 it shows the strong Cronbach's alpha reliability value of guideline that “Fix places of home and power buttons”. In addition, participants give his opinion regarding the home button that takes them easily to the main menu. It is very comfortable for VIP that the home key button takes them back home if the wandering in the menu items.

The competent and natural user experience can be provided for different user groups by smart mobile devices[31][32]. For VIP there should be a specific consideration that must be given to the requirements of mobile applications. In order to increase the proficiency and confidence of mobile phone applications for VIP suitable design should be applied. There should be a properly accessible design layer for VIP that can be provided the VIP best accessibility factors.

The particular accessibility tool has specified to design the mobile phone application for VIP. There is not an accomplished a general list of guidelines in order to develop an accessible design of mobile applications for VIP. In this paper, through the involvement of VIP, the requirements of mobile applications were prepared. There are many design principles that are the same that was applied to previously designed mobile phone applications[6].

5. Requirements of Mobile Application Design

1. Mobile phone size easy to fit in the hand
2. A mobile device should be bearable with wet drops and scratches.
3. The home button is detectable easily.
4. There are proper spaces between buttons and edges of buttons are clear.
5. The place of home and power button should be fixed.
6. The popup/voice message of error notification should be proper.
7. There should be proper voice notification of the availability of signals and battery deadline.
8. The main menu should be on the left corner of a mobile device and easily accessible.
9. The display screen should be high-resolution with proper contrast of text.

10. Text entry, text searching, and dialing a phone number should be Voice activated.
11. There is no grouping of menu items due to there is confusion in selecting the proper menu item.
12. There should be a notification of every completed task.
13. Self error correction must be available.
14. Speed dialing also available.
15. The cursor should be blink at the entry area.
16. The entered character's name must be heard.
17. When VIP touched an item its name should be heard.
18. Sound feedback can easily turn off if it is no more required.
19. Easily adjustable volume during the calls.

6. Conclusion & Future Work

There are some limitations in this paper, due to limited resources the very fewer participants have participated in it but they fulfill the requirements. The participants that take part in this paper have no specific type of visual impairment. It will more helpful if select the specific type of visual impairment. Another limitation is that only those participants were selected who have more than two years of experience for using mobile applications. In order to select the participants with different mobile phone usage experience, there will be more chances to increase the accessibility of mobile phone applications. Another limitation of this paper is that it is only the suggestion collected on the experience-based and not implemented at any mobile device. In order to improve these design guidelines, it should be applicable to any mobile application. In the future, these guidelines will be implemented at any mobile application design with the involvement of VIP. In the future, these results can be used to design mobile applications for VIP.

7. References

[1] Hammel, J., Magasi S.: What does participation means? An insider perspective from people with disabilities. Disabil. Rehabil. 30(19):1445–1460 (2008)
[2] ETSI EG 202 116 Human Factors (HF); Guidelines for ICT products and services; ‘‘Design for All’’ (2002).
[3] Zimmermann, G.: Access Technologies Group: Resources. http://www.accesstechnologiesgroup.com/Resources (2006).
[4] Yatani, K., Truong, K.N.: SemFeel: a user interface with semantic tactile feedback for mobile touch-screen devices. In:User Interface Software and Technology (UIST), pp. 111–120. ACM, New York (2009).
[5] Spinuzzi, C.: The methodology of participatory design. Appl. Res. 52(2), 163–174 (2005).
[6] World Health Organization (WHO), Visual Impairment and Blindness Fact Sheet. http://www.who.int/mediacentre/factsheets /fs282/en (2089).
[7] McGookin, D., Brewster, S., Jiang, W.: Investigating Touchscreen Accessibility for People with Visual Impairments. Paper presented at the NordiCHI 2008 Lund, Sweden (2008)
[8] Smith-Jackson, T.L., Nussbaum, M.A., Mooney, A.: Accessible cell phone design: development and application of a needs analysis framework. Disabil. Rehabil. 25(10), 549–560 (2003).
[9] Hannukainen, P.: Disabled Persons as Lead Users in Mobile User Interface Design. Helsinki University of Technology, Espoo (2005).
[10] Guerreiro, T., Lagoa, P., Nicolau, H., Gonalves, D., Jorge, J.A.:From tapping to touching: making touch screens accessible to blind users. IEEE Multimedia 15(4), 48–50 (2008)

[11] Guerreiro, T., Montague, K., Guerreiro, J., Nunes, R., Nicolau, H., Gonc¸alves, D.: Blind people interacting with large touch surfaces: strategies for one-handed and two-handed exploration. In: Proceedings of the 2015 International Conference on Interactive Tabletops and Surfaces, pp. 25–34 (2015)
[12] Harada, S.: Accessible photo album: enhancing the photo sharing experience for people with visual impairment. In: CHI 2013: Changing Perspectives, Paris, France, pp. 2127–2136 (2013)
[13] Hatwell, Y., Streri, A., Gentaz, E.: Touching for Knowing: Cognitive Psychology of Haptic Manual Perception. John Benjamins Publishing Company, Amsterdam (2003)
[14] Holzinger, A.: Finger instead of mouse: touch screens as a means of enhancing universal access. Comput. Patient Educ. Lect. Notes Comput. Sci. 2615, 387–397 (2003)
[15] Irwin, C.B., Sesto, M.E.: Performance and touch characteristics of disabled and non-disabled participants during a reciprocal
[16] tapping task using touch screen technology. Appl. Ergon. 43, 1038–1043 (2012)
[17] Jayant, C., Ji, H., White, S., Bigham, J.P.: Supporting blind photography, pp. 203–210. Proc. ASSETS, ACM (2011)
[18] Kaiser, H.F.: An index of factorial simplicity. Psychometrika 30, 1–14 (1974)
[19] Kane, S.K., Jayant, C., Wobbrock, J.O., Ladner, R.E.: Freedom to roam: a study of mobile device adoption and accessibility for people with visual and motor disabilities. In: Proceedings of 11th International ACM SIGACCESS Conference on Computers and Accessibility, Pittsburgh, Pennsylvania, USA (2009)
[20] Kane, S.K., Bigham, J.P., Wobbrock, J.O.: Slide Rule: making mobile touch screens accessible to blind people using multi-touch interaction techniques. ASSETS'08, pp. 73–80 (2008)
[21] Oliveira, J., Guerreiro, T., Nicolau, H., Jorge, J., Gonc¸alves, D.: Blind people and mobile touch-based text-entry: acknowledging the need for different flavors. In: Proceedings of ASSETS '11, pp. 179–186 (2011).
[22] Vidal, S., Lefebvre, G.: Gesture based interaction for visually impaired people. In: Proceedings of 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries, pp. 809–812 (2010).
[23] Kane, S.K., Wobbrock, J.O., Ladner, R.E.: Usable gestures for blind people: understanding preference and performance. In: Proceedings of SIGCHI Conference, pp. 413–422 (2011).
[24] Yfantidis, G., Evreinov, G.: Adaptive blind interaction technique for touchscreens. Univ. Access Inf. Soc. 4(4), 328–337 (2006).
[25] Plos, O., Buisine, S.: Universal design for mobile phones: a case study. In: CHI '06 Extended Abstracts on Human Factors in Computing Systems, pp. 1229–1234 (2006).
[26] Nancy, F.K.: Computer Technology, Education and Disability: Experiences of Postsecondary Students Who are Blind or Visually Impaired (Unpublished Doctoral Dissertation). New York University, New York (2006).
[27] Kane, S, Bigham, J., Wobbrock, J.: Slide rule: making mobile touch screens accessible to blind people using multi-touch interaction techniques. ASSETS'08:73-80 (2008).
[28] Zhang, D., Adipat, B.: Challenges, methodologies, and issues in the usability testing of mobile applications. Int. J. Human-Computer Interact. 18(3), 293–308 (2005).
[29] Gould, J.D., Lewis, C.: Designing for usability key principles and what designers think. Commun. ACM 28(3), 300–311 (1985).
[30] Kujala, S.: User Studies: A Practical Approach to User Involvement for Gathering User Needs and Requirements. Helsinki University of Technology, Espoo, Finland (2002).
[31] Rust, K., Malu, M., Anthony, L., Findlater, L.: Understanding child defined gestures and children's mental models for touchscreen tabletop interaction, pp. 201–204. Proc. Inter. Des. Child., ACM (2014).
[32] Gao, Q., Sun, Q.: Examining the usability of touch screen gestures for older and younger adults. J. Hum. Factors Ergon. Soc. 57, 835–863 (2015).