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TOWARDS USER-CENTRIC STANDARDIZATION OF MOBILE APPLICATIONS DESIGN MODEL FOR VISUALLY IMPAIRED PEOPLE

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Abstract. *In order to perform everyday activities, a large number of Visually Impaired People (VIP) use mobile applications. The lives of Visually Impaired People (VIP) have gain strength with the use of mobile applications. There are many mobile applications that have still problems for VIP when they use these mobile applications. There are many types of research that are making efforts to solve the problems faced by VIP. There are many operating systems for different mobile applications that support Visually Impaired People (VIP). The better user experience can be provided to VIP by review again on existing mobile applications. This paper observed the patterns of VIP to using mobile applications, in order to fulfill the goal of user-centric standardization of mobile application for visually impaired people. In this paper, 25 VIP participated in performing the task. In the result of observation, there are a lot of usability and accessibility problems during using mobile applications. This paper also suggested the guidelines for user-centric standardization of mobile applications for VIP on the basis of their wishes. In order to conclude, it is suggested that there is a need for user-centric standardization of mobile applications to improve the present conditions of mobile applications for VIP.*
Keywords: Visually impaired people, Mobile application, User-centric standardization, Visual impairment

1. **Introduction.** That the normal level of eyesight is not on its normal condition is known as visual impairment, according to the Center for Disease Control and Prevention USA [1]. In other words, if a person loses some part or a whole part of his ability to see then he is infected with visual impairment. With the help of contact lenses, eyeglasses, and surgery this visual impairment can be controlled. In the year 1975, according to the first worldwide estimation in the extent of visual impairment, it was indicated that around 28 million people were blind. In the year 1990, on the bases of another estimation there were 38 million blind people and almost 110 million with low vision [1]. In the year 1996, this estimation explored again on the current world population, according to this 45 million people were blind and 135 million with low vision. When this same estimation projected to 2020 population in the findings 76 million people will be blind. This visual impairment caused due to the proportion of treatable causes of blindness or treatable eye diseases, such as children eye conditions, trachoma, cataract, and onchocerciasis. The estimated cause of visual impairment is described in Table 1.

Many visually impaired people used mobile phones to reach applications, books, and Internet access. According to research experience most of the visually impaired people using these mobile devices to see image enlargement after taking some photos, the camera flash is used as a torch when they feel that the environment has low light.

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TABLE 1. The estimation of visual impairment caused by the Vision Loss Expert Group in 2015

Cause	Blind		Moderate to severe visual impairment		All visual impairment	
	< 3/60 to no light perception (NLP)		< 6/18-3/60		< 6/18-NLP	
	No. millions	%	No. millions	%	No. millions	%
Cataract	12.6	35	52.6	24	65.6	26
Uncorrected refractive error	7.4	21	116.3	54	123.7	49
Glaucomas	3	8	4	2	7	3
Age-related macular degeneration	2	5	8.4	4	10.4	4
Corneal opacity	1.3	4	2.9	1	4.2	2
Trachoma	0.4	1	1.6	1	2	1
Diabetic retinopathy	0.4	1	2.6	1	3	1
All other causes	8.9	25	28.2	13	37.1	14
Total	**36**	**100**	**217**	**100**	**253**	**100**

The aim of this paper is to observe how VIP use mobile phone applications and point out the problems they face during using mobile applications. This paper also suggests some guidelines to standardize the mobile application according to the difficulties of VIP.

The remaining part of this paper is organized as follows. Section 2 describes background & literature review. Section 3 describes the methodology of the experiment. Results of experiments are discussed in Section 4. Guideline for User-Centric Standardization of mobile applications to enhance the accessibility of VIP is introduced in Section 5. The conclusion and feature direction are described in Section 6.

2. **Background & Literature Review.** While reviewed a lot of researches it is noticed that mobile phone organizations have been remarkable interest in developing many new mobile phone applications for VIP. In performing a daily task, VIP is supported by both iOS and Android mobile applications. Sighted people also used many of these mobile applications for good effects. There is a quick overview of many solutions provided by both platforms.

In order to read barcodes and QRcode, the applications ScanLife Barcode and QR Reader [2] are used by VIP. In supermarkets and other public places, it is useful for reading the codes but high memory demand is a problem in it. The Eyes-Free Shell is an application that provides the facility to VIP for open alternative home screen or launcher. There are many ways of interaction provided by this application like a direct dial to contacts, launching an application, checking status information, sending a message [3]. JustSpeak is another application that enables the VIP to control the screen commands, trigger some basic Android activities, and launched applications [4]. In different conditions, many Android applications are available that provided the navigation facilities to VIP. Talking Location is a navigation application that updates the VIP to their location with the help of mobile data signals by device shaking or connectin with WiFi [5]. This application also helps the user to send SMS from their location to friends. In order to facilitate a straight-line walking, several applications are developed [6,7].

On the iOS platform, VioceOver is the most important application due to the fact that it provides screen reading abilities for Apple's local application and also many other

third-party applications developed on iOS platform. VoiceOver can be used with the help of fingers and VIP can control their mobile device from it. Another mobile application is Voice Brief for reading feeds, weathers, emails, and news [8]. Dragon Dictation is an application that helps the VIP to translate the voice into text [9]. The Recognizer application helps VIP to recognize ID cards, packages, cans through a camera-based barcode reader [10]. The LookTel MoneyReader recognizes the currency and tells its dimension, counts the total and easily identifies different bills for VIP [11]. Color ID Free is a color identification application also offered by iSO platform [12]. In order to help the VIP, the TapTapSee application is used to identify the objects in their daily lives [13]. VizWiz is an application that takes a picture from a camera and records the question about it [14]. The Headphone application is used to listen to the headphone while surrounding sounds also hearing [15].

In brief, there is a need for speed up investigation in the usability of mobile applications. This is also need to redesign the current mobile applications that are according to the hopes and requirements of VIP. There are many researchers that are a focus on accessible and user-friendly mobile application design based on Human-Computer Interaction (HCI) guidelines. However, there is a need for further enhancement in results from the literature review's findings in an area of accessibility, usability, and requirements of VIP.

3. **Methodology.**

This paper specifically presents the results of VIP tasks which they performed on their mobile phone applications. The identification of visual impairments has been categorized by the use of mock optics. Some factors have investigated the user expectations of VIP regarding touchscreen smartphones. Here is a measurement of user's satisfaction, effectiveness, and efficiency during performing the different task.

3.1. **Participants.**

There were a total of 25 people participated as visually impaired. It is to be considered valid in the geographic area specifically with VIP if that study has 20-30 participants. In a study there are 5-10 VIP taking part, it is generally enough for research specifically on the people with visual impairment [16]. There are a total of 17 males and 8 females with 24.8 average age. Only those people were selected, who have been experienced using the smartphone for more than two years and who have diagnosed by moderate and severely level of the visual impairment. Around thirteen participants had achieved higher than secondary school education and the remaining have only elementary school education. All moderate and severely VIP were selected according to the World Health Organization (WHO). The introductory guidelines about each task are described to all the participants separately. They also taught significance and measure about the assigned task to the participants.

3.2. **Task design.**

The touchscreen-based smartphones are included as the main material for the experiment. Interactive task on a mobile interface is provided for an experiment. Feature of a touchscreen is accessible by the participants as an experience. An Android smartphone having a 5-inch screen and multi-touch functions were presented as an experimental stimulus. In this experiment, four tasks are executed; one of them is basic and three are advanced level. Each task is divided into two parts, in the first part VIP perform the task without third-party applications and in the second part they are allowed to use those third-party applications. The complete specification of all tasks is the following.

Task One (*Settings*). On the mobile screen, the user can slide the screen and choose a service from the mobile, such as the sound of an object (yes or no), the density of information (low or high), brightness variation (dark or light). After the implementation of that service, it will automatically come back to the main screen. To fulfill this task is difficult to VIP without mobile built-in application. Therefore, with the help of built-in mode, it may be easier to complete the task.

Task Two (*Upload Photo*). From the mobile phone select the camera and capture a photo. After capturing it is automatically saved in the mobile phone. The VIP select that photo and upload it on social media like Facebook, Whatsapp. When the user completes its step so it comes back to its main screen automatically.

Task Three (*Upload Status*). The VIP write a status and upload it on social media like Facebook, Whatsapp. When the user completes its step so it comes back to its main screen automatically.

Task Four (*Likes & Comments*). The VIP received comments & likes against his picture and status, so he opens the comment box and reads that comments with the help of magnifying glass app available in his phone, same procedure to his likes on the picture and status. When VIP complete the task the application comes back to its original point.

4. **Experimental Results.** The rules and purpose were briefed to all the participants before starting the experiment. On provided touchscreen mobilephone, all the participants performed the four experience tasks, from which three are advanced level and one is a basic level. For each user, the time allowed for each task is approximately 10 minutes.

4.1. **Data analysis.** The measurement of usability includes three basic parameters, one is effectiveness, second is satisfaction and the third is efficiency. That the number of goals is measured and achieved is called effectiveness. A standard ISO 9241-11 is described to identify the information that measures the usability, performance and effectiveness. The response was observed as "Not Completed", "Partially Completed", "Completed with Help" and "Task Completed". Each VIP has performed the task into two portions; one is with the help of a mobile assistive application and second is without the mobile assistive application. The score of response from each group is shown in Figure 1.

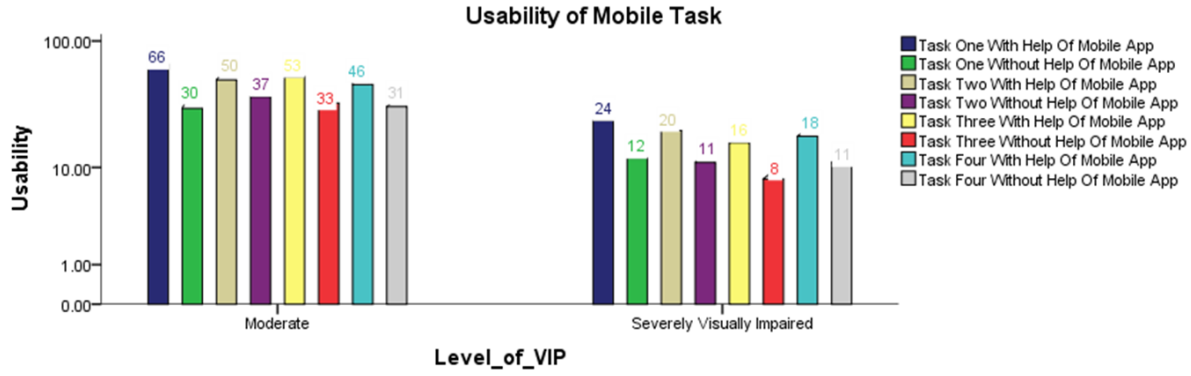

FIGURE 1. Usability comparison for VIP

In Figure 1 the report shows the usability of VIP groups. The results show for Task One that moderate visually impaired people performing the usability by the help of the assistive mobile application is 66%, and usability without the help of the assistive mobile application is 30%. In Task Two usability by the help of assistive mobile application is 50% and usability without help of an assistive mobile application is 37%. In Task Three usability by the help of assistive mobile application is 53% and without help of an assistive mobile application is 33%. In Task Four usability by the help of assistive mobile application is 46% and without help of an assistive mobile application is 31%. In the case of severely visually impaired people performing the usability of Task One by the help of assistive mobile application is 24% and without the help of the assistive mobile application is 12%. In Task Two usability by the help of assistive mobile application is 20% and without help of an assistive mobile application is 11%. In Task Three usability by the help of assistive mobile application is 16% and without help of an assistive mobile

application is 8%. In Task Four usability by the help of assistive mobile application is 18% and without help of an assistive mobile application is 11%.

4.2. **Accessibility features.** In all tasks the VIP perform accessibility features. The usage rate of accessibility features has a great difference between moderate and severely VIP. The moderate VIP used the visual features (zoom, text enlargement, and color contrast, buttons access, feedback to VIP, screen size and edges) to fulfill their tasks. The people with severe visual impairment used verbal output due to the fact that they had a severe problem to see and explore mobile applications.

4.3. **Text entry.** Voice input is used by severely VIP and moderate VIP used flick input method to fulfill their text input requirements. These inputs were followed by numeric keyboard, QWERTY keyboard, and external keyboard. Out of 19 moderate VIP, 6 used different input methods other than keyboards. This is also observed that VIP select the text input methods according to the conditions. When they need to enter a long sentence for texting then use keyboard otherwise they use voice inputs for short messages or searches.

4.4. **Wishes of VIP.** In the open-ended questionnaire, it also asked which of the phone is more convenient to use either smartphone or feature phones. Most of the severely (79.0%) and moderate (71.0%) VIP respond that feature phones are less convenient than smartphones. On the other hand, some of severely (71.2%) and almost half of moderate (50.3%) VIP responded that smartphones were difficult in use. From this result, it is clear that severely VIP have faced more problems and difficulties in using the smartphone. From the same questionnaire, the wishes of VIP also asked about the mobile phone applications. The VIP told that there is a problem of accessibility when they have used the functions of a mobile application. There is no substitute text for mobile application unavailability; hence it is also created a problem for VIP. There is an only soft keyboard in smartphones for text entering, due to that extra time needed to input a text and correction of mistakes. It also takes time even if VIP used the auditory and visual tools. The screen reader also gives an inaccurate and low standard verbal output of the screen reader. Some VIP have suggested improving the reading applications due to the fact that some mobile application does not allow magnifying their characters.

5. Guideline for User-Centric Standardization of Mobile Applications to Enhance the Accessibility of VIP.

5.1. **Buttons.** The place of the main function button in a mobile application should be the specific place of touch screen like a corner of an application and edges of buttons are shown properly. In touchscreen mobile, a physical button should be an affiliate with the main function of a mobile application.

5.2. **Data input.** There should be many sections and menus to divide the alphabets when VIP using the virtual keyboards. There should be proper space and location identifications of all keys. In entering a character from the keyboard must confirm and maintain the time for entering each character. Multifunction on the same key should be avoided.

5.3. **Interaction with a gesture.** Through verbalization, notification, and vibration the gesture of mobile application can be improved. For problems related to VIP the gesture can be created in standard language. In order to make the gesture identification flexible the modification required in execution speed. Make the gesture adaptable according to VIP's features and gesture can be made according to recent gesture.

5.4. **Reading the screen/screen reader.** With the help of using gesture, virtual and physical shortcuts buttons can produce more options to the linear paradigm of screen reading. There should provide more languages for readings. The setting of speech speed should be allowed. There should be easy access to a button that allows instant intervention for reading.

5.5. **Voice comand.** There must be a physical button that should work as a stand-by to activate the voice command. There should be a universal control for the device, comparatively for a few applications. There should be an identification of multiple voice commands at a single time. The voice identification should be in multiple accents and languages.

6. **Conclusion and Feature Works.** The experiments follow through a procedure during the evaluation of the usability of the tasks but still, there are some limitations. This study focuses only on Facebook and Whatsapp with the help of VoiceOver and iPhone. iPhone comes into the luxury categories so all the VIP are not able to take it, especially in the developing countries [17]. In this study, the data of participants background information such as their history, the cause of visual impairment does not include. In this study, only "Moderate" and "Severe" levels of visual impairment are discussed. The usability testing in this study did not consider the effects of diverse environments, due to this testing conducted in the lab environment. In the usage of smartphones, the situational effects like walking, time effects, and crowded spaces can greatly influence the ability of visually impaired people [18].

VIP have their own unique experience of interaction when they are using mobile applications. That experience creates a huge distance between the need for VIP and the creative ideas of mobile application designers. In developing the new mobile application for VIP, this distance has a challenge for all the mobile application developers. If VIP considered as a part of mobile application development then maybe we can overcome this distance. This study analyzed the usability and interaction of VIP with the different task of mobile applications. This study also indicates the usability testing of different mobile tasks. The usability factors and expectations of users were also investigated regarding tasks on touchscreen-based mobile phones. The results of this study will also help and facilitate the touchscreen-based mobile phones application developers for VIP. The future work will focus on improving the current mobile application for VIP and need to define a user-centric standardization of mobile application for VIP.

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