International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:8, No:5, 2014

Usability Issues of Smart Phone Applications: For Visually Challenged People

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***Abstract*—**In this era of globalization, adoption of technology is quite difficult for people with physical disabilities compared to people with normal abilities. The advancement in mobile based accessible applications have opened up several different avenues for the visually challenged across the globe. Smartphones applications are not very common for blind people, but they access and use these applications in their daily lives to some extent. Several smartphone applications have a number of usability issues for the visually impaired. In this paper, we evaluate the usability of various android & iPhone applications for blind people through analysis and surveys. This paper aspires to provide guidance in order to increase smartphone application accessibility for the visually impaired. An abstract application design is also proposed to overcome usability issues in smartphone applications for visually challenged people.

***Keywords*—**Eyes-free shell, human computer interaction, usability engineering, visually challenged.

I. Introduction

THIS human sensory system plays a very important role in our daily lives but most of the time these are taken for granted. For a long time, the visually impaired were deprived from getting the benefits. Although the advanced state of technologies has opened up creative ways for these persons, unfortunately, visually impaired people lack the ability to gather the required visual information. An unknown environment can be unsafe, unpleasant, and uncomfortable for people having the disability of blindness. In spite of this, they compensate their disability by creating mental maps from sensory images [1].

People who are visually challenged still struggle every day in performing actions that can be simple. "*Software systems that do not satisfy the users are often having poor and incomplete design. The poor and incomplete design can be due to systems designers and developer's failure to involve users in the development [2]*".

According to National Eye Institute (NEI), in 2010 U.S. has 66% prevalent cases of blindness in female and 34% in male [3]. This is an evidenced fact [4] that there are many softwares developed today are still inaccessible to visually challenged people just because of their accessibility and usability issues.

According to the World Health Organization (WHO), in June, 2012 more than 285 million people worldwide are visually challenged, 39 million are blind and 246 have low vision. More than 82% of them are 50 years of age & older and 90% of the world of visually challenged people live in developing countries. The World Health Organization (WHO) also esteems at 180 million people that are affected by the visual deficiencies, among which 40 to 45 million are fully blind; these numbers can be doubled in 2020 [5].

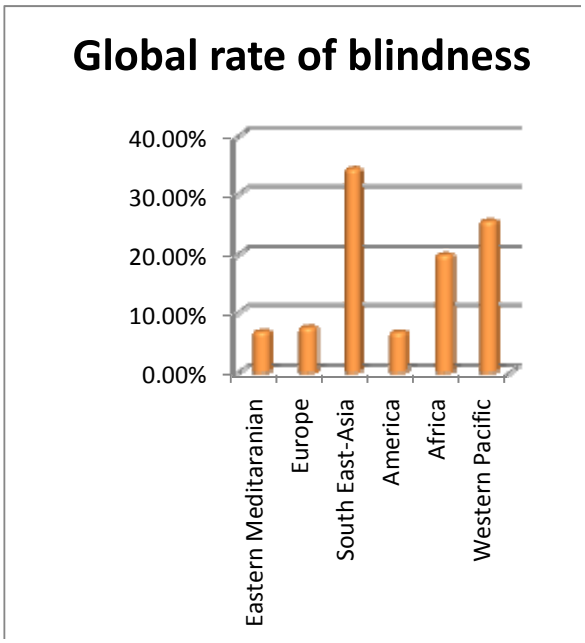

Fig. 1 Global rate of blindness

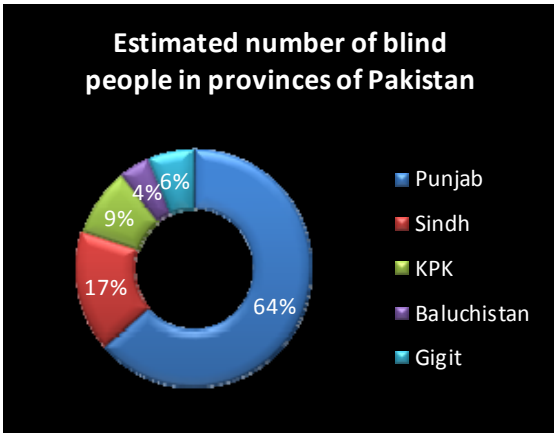

Fig. 2 Estimated numbers of blind people in provinces of Pakistan

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The WHO [5] geographical distribution of global blindness is shown in Fig 1.

According to the "Pakistan National Blindness" visual impairment survey, [6] reported that Punjab has 769,000, Sind has 200, 000, Khyber pakhtoon khwa (KPK) has 114,000, Baluchistan has 52,000 and Gilgit has 47,000 blind people in these provinces of Pakistan. Estimated number of blind people in different provinces of Pakistan is shown in Fig 2.

Smartphones often provide blind users with the best accessibility via separate screen reading software such as Spoken Web, Mobile Speak etc. [7].

The uptake of screen reading software among visually challenged users is limited due to its high cost. Google's Android platform and the Apple iPhone 3GS now include free screen readers that support visually challenged people such as Eyes Free, Voiceover etc. [8], [9].

Smartphones have proven their fame among visually challenged users, which enthusiast us to concentrate on smartphone applications that are specially designed for visually challenged people. General-purpose smartphones applications take initiative to replace special-purpose devices, but visually challenged people still pick different devices such as light detector, barcode readers, and color identifiers [10]. Some accessible applications that use camera of existing phones include color identifier and currency-reading applications [11], [12]. The incorporated motion sensors in the smart phones have been used for videos stabilization [13].

This research is conducted on how to make smartphone applications more accessible and usable for visually challenged people. Comparative analysis is performed on the basis of survey conducted on the visually impaired people.

The main aim of this paper is to highlight usability and accessibility issues in two different smartphone's applications and propose a new design to enhance their usability and accessibility for visually challenged people.

This paper includes ii) related work, iii) research methodology, iv) comparative analysis of software application for blind people, v) findings on the basis of comparison, vi) new application design on the basis of comparison of two applications, vii) conclusion and future work.

II. Related Work

Blind people are considered as being sub-human and unfit to take part in society's mainstream activities. [14]. Most current assistive technologies for visually challenged users are platform dependent, difficult to use, and expensive.

A new approach by the US (United State) National Library of Medicine (NLM), National Institutes of Health (NIH), addresses these limitations by identifying the assistive capability at the server, thus freeing visually challenged individuals from the software expense, technical complexity, and substantial learning curve of other helpful technologies [14].

Blindness is considered to be the most feared disability among all others. Over the last few years, the industry of entertainment and technology has been on the rise for facilitating learning and rehabilitation environment to visually impaired people. Orly and David developed new virtual environment system for the assistance of visually impaired people in their exploration and cognitive mapping of strange surroundings [15], [16]

For sensory substitution systems, many efforts have been made to aid blind people to access visual information such as text, graphics, or images [17], [18].

In [19] Avizzano and Marcheschi transcribed the visual information of the screen and made it available to the haptic senses for blind person, by using a prototype two-axis HI, the Moose.

The visually challenged people mostly obtain information in the form of audio by using different technologies together with Text To Speech systems and a mobile based database to support visually challenged people.

In [20], Une presented information presentation device for active understanding to assist blind people. Imai, Tazawa [21] have developed touch screen application for the retrieval of speech information that help sighted people as well as visually impaired people.

"Ray" [22] is the first developed smartphone having eye free operations. This smartphone has been launched to transform the lives of many blind people and to see their world. The "Ray" smart phone has been designed to endure in the life of visually challenged people. It also provides eyes free shell and allows a blind people to utilize the speech capability [22].

According to ISO 9241 standard, usability is the *"extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [23].*

According to ISO 14289*"The degree to which a product, device, service, or environment is available to as many people as possible, including users with disabilities" [24].*

III. Research Methodology

One of the most common problems that many blind people face is their day-to-day challenge in enduring with their impairment. Losing all of your sight can be very distressing and have a big effect on life. It results in struggle with a range of emotions from anger and frustration, to depression and grief. In this situation of frustration, smartphones is considered to be marvelous potent tools for blind people [25].

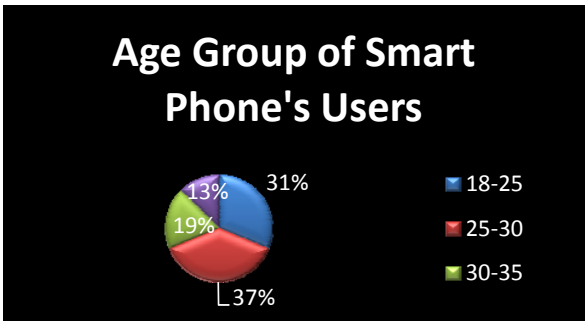

Fig. 3 Age group of smartphone users

For our research study, we approached 80 visually impaired people who have experience of using smartphone applications for last 2 years. We requested them to use android application named TalkBack [26] and iPhone application named VizWiz [27]. They were requested to use each application for an hour and then fill the questionnaire. Among the 80 participants 25 were in the age range of 18-25years. 30 users fell in the range of 25-30 years, 15 were between the ages of 30-35 years and the remaining 10 were above 35 years of age. This age information is shown in Fig 3.

The survey was conducted in Islamabad, Pakistan and in Beijing, China. In Pakistan, we approached an institute called Pakistan Foundation Fighting Blindness (PFFB) and blind students of different universities of Pakistan. However, multiple Facebook groups for visually challenged people also proved to be of great help in accomplishing successfully our survey. We have also approached smartphone users of different countries via Google groups. We approached 150 blind people and distributed questionnaire, but only 80 users provided us with their feedback.

From Pakistan we got response from 30 visually challenged users, and from China 40 users provided us their feedback and rest of the 10 respondents were from different countries India, Ontario, Memphis and New York.

Out of 80 participants, 55 were android users and remaining 25 were iPhone users and 15 were those who used both smartphones. The distribution of different smartphone users is shown in Fig 4.

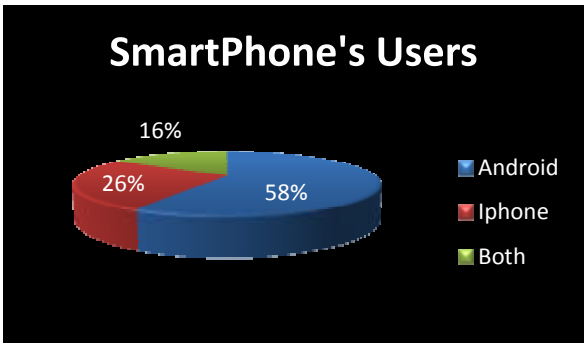

Fig. 4 Distribution of different smartphone users

The questionnaire was distributed among visually challenged people in electronic text file format. All participants filled out the questionnaire themselves and sent it back to us by email. It was assured to all the participants of the study that their personal data would be kept confidential. The participants were asked 25 questions; few were open-ended and remaining questions were about

- Ease of learning,
- Efficiency in use,
- Satisfaction,
- Feedback and good error messages,
- Adequate help and documentation and
- Accessibility

The five-point Likert Scale was used for each question. The participants were asked to specify the extent of their agreement or disagreement using this scale. The scale ranged from “strongly agree” (1) to “strongly disagree” (5). Optional suggestions were also recorded to know their overall experience and to get the participant’s overall idea of the application. Questions were also asked about positive, negative and required feature of applications that are missing in these particular applications

IV. Analysis of Existing Smartphone Application for Visually Challenged People

There are number of applications that are available on Application Store and on Google Play for blind people, but most of them are paid. The application chosen for this study is free of cost. Blind people can easily download, install these applications and can use on their smartphone.

It was noticed that the applications that are available for free of cost, lack accessibility and usability [28]. Therefore we perform the analysis based on user reviews of existing applications that are available in the market. After the review, we propose a design for these applications to fulfill needs of user’s in a far better way.

The applications that we have selected for analysis are for android and iPhone domain. The Android application under analysis is:

A. TalkBack [26]

The application is a project of “Eyes-free” to facilitate blind people. It is an open source screen reader for visually challenged people. It includes many different interesting features of accessible spoken, audible, and vibration feedback, directional control etc.

The iPhone application that analysed is:

B. VizWiz [27]

VizWiz is designed by “Rochester Human Computer Interaction” to help blind users to receive quick answers to questions about their surroundings. VizWiz is designed on the behavior of automatic image processing (AIP).Users take a picture with their phone, speak a question, and then receive multiple spoken answers.

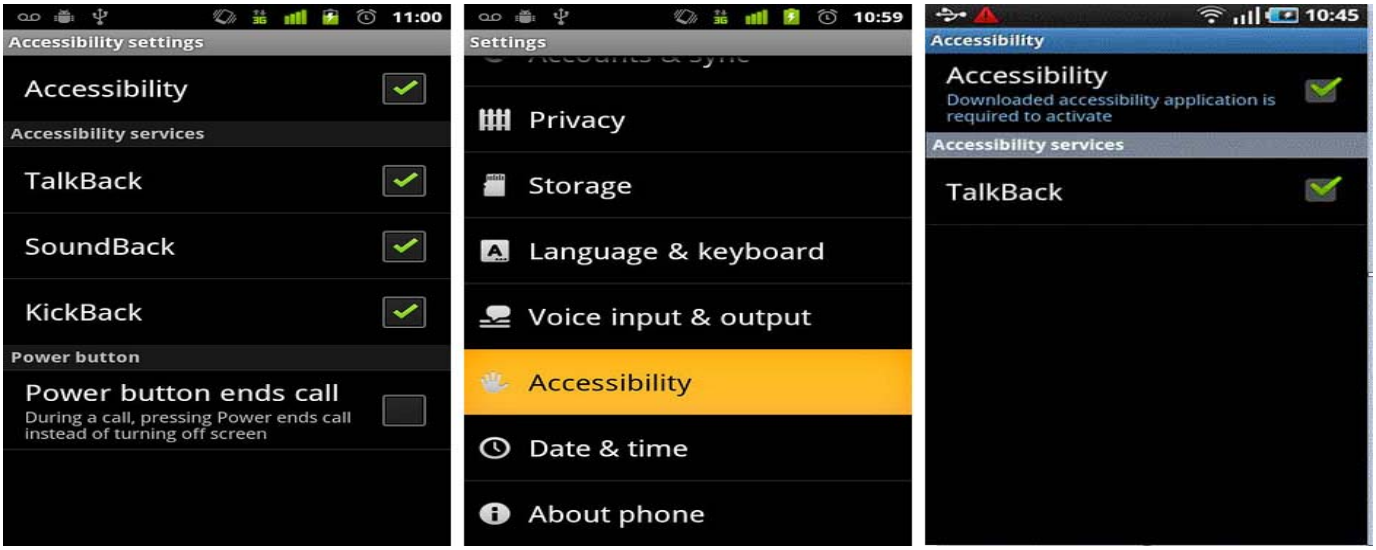

Fig. 5 Screenshot of TalkBack [26]

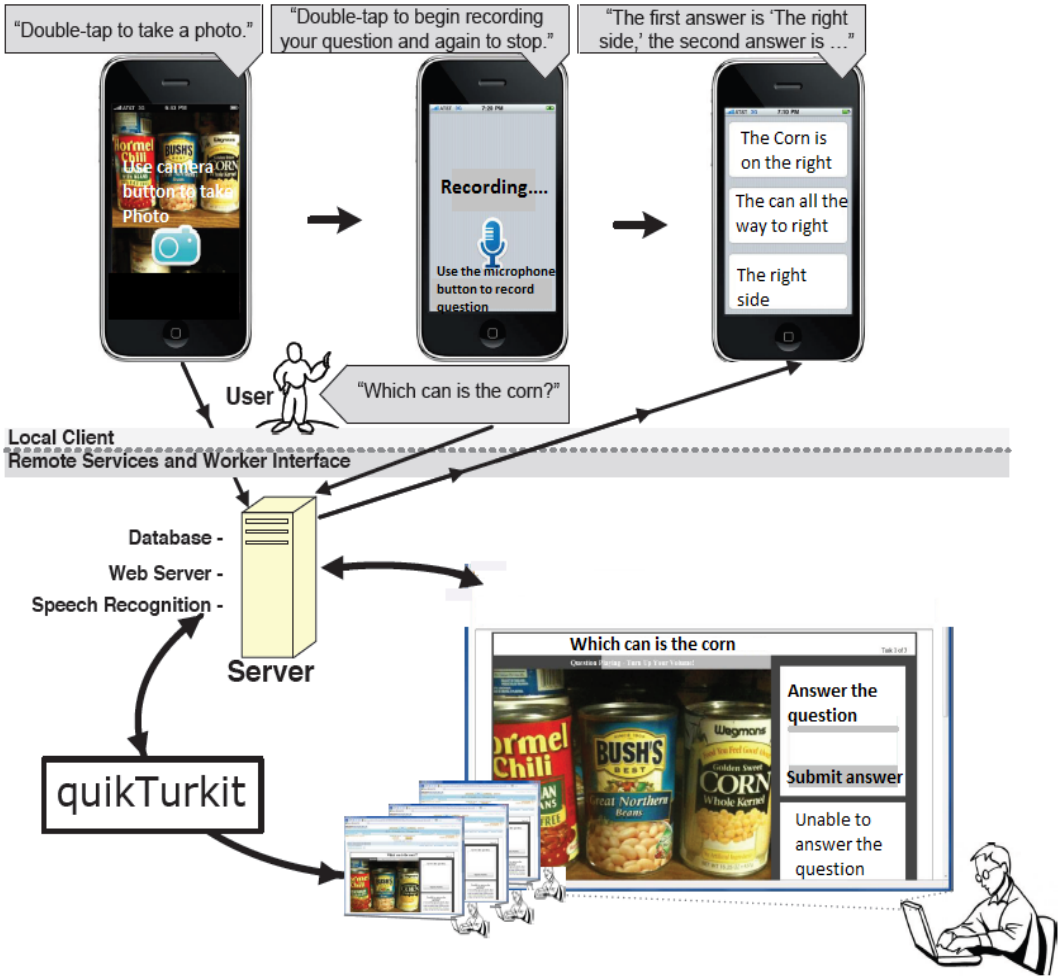

Fig. 6 Screenshot of VizWiz [29

V. Findings

For measuring usability and user experience, usability matrices play very important role. By gathering different matrices we can analyze usability of any application.

Table I shows the different usability matrices and their evaluation. These results are obtained by conducting questionnaire survey.

A. Usability and Accessibility Analysis of TalkBack and VizWiz

After conducting survey and concluding finding we have come up with different negative and positive aspects of smartphone applications, as aspects highlighted by visually impaired users.

TABLE I
Evaluation of Usability Matrices

Usability Matrices	Android TalkBack	iPhone VizWiz
Ease of learning	55% of the users found TalkBack easy to learn	70% users found it easy to learn
Efficiency in use	40% users found it efficient to response	64% users found it efficient to response
Satisfaction	30% users were not satisfied of Talkback application.	About 20% users were not satisfied of VizWiz application
Feedback and good error messages	58% of users were of the opinion that feedback, an important part of usability was found lacking in TalkBack	45% of users were of the opinion that feedback, an important part of usability was found lacking in VizWiz
Adequate help and documentation	20% of the Talkback users were satisfied with documentation	35% of the VizWiz users were satisfied with documentation
Accessibility	60% of the Talkback users found it accessible	75% of the VizWiz users found it accessible

B. Positive and Negative Aspects of TalkBack Application:

TABLE II
Positive and Negative Aspects of Talkback

Positive aspects	Negative aspects
Digestible and less robotic- About 98% users were of the opinion that, it read certain phrases, which makes reading longer articles in natural sound	**Limitation of Installation**- About 90 % of the user reported that there is no good way to install and launch talkback and cannot install talkback by ourselves.
Appealing Layout- About 87% users appreciated the overall layout of the application but with more improvements.	**Ineffectual to read**- About 60% of the users complained about that application speaks something which is not being displayed on the screen.
Effective mode of sound back- About 94% users were of the opinion that if the issues of settings and shortcut icon were addressed properly this app could be very helpful for blind people to sound back.	**Limited Text to Speech (TTS)** - About 87% of the users were of the opinion that only one TTS voice which Google offer is not sufficient.
Valuable accessibility- About 65% users appreciated accessibility of different option using this application	**Create Shortcut**- About 75% users reported their complained that application don't allow users to create a shortcut for Talkback, that we can launch it by running.
Easy to navigate- About 71% users found it easy to navigate through the application and search for respective items.	**Naming of unnamed button**- About 70% users were of the opinion, if there are different button at the same position, talkback cannot distinguish them.

C. Positive and Negative Aspects of VizWiz Application:

TABLE III
Positive and Negative Aspects of VizWiz

Positive aspects	Negative aspects
Fast and Accurate- About 98% user appreciated its accuracy and fast recognition of objects	**Center Objects**- About 87% user noticed that you have to center the object as much as you can
Fully accessible- About 72% users were of the opinion that it is too good and easily accessible	**Text Question feature**- About 98% users noticed that application is unable to include text question
Twitting question- About 86% users appreciated option of tweeting your question via Twitter	**Drain of Battery**-About 65% users was of the opinion that application continues tracking location even after you close it. Obviously this could be a major drain on your battery.
Twitting question- About 86% users appreciated option of tweeting your question via Twitter	**Drain of Battery**-About 65% users was of the opinion that application continues tracking location even after you close it. Obviously this could be a major drain on your battery.
Responsive I.Q engine- About 96% users found that VizWiz I.Q engine responds in less than 30 seconds.	**Limitation of Internet availability** -About 80% users were of the opinion that it should work without internet availability by using own local database.
Multiple answerers- About 72% users appreciated the answering ability of multiple questions at a time.	**Rely on Volunteer** -About 98% users were of the opinion that it should not rely on volunteer instead of its own I.Q database.
Effective mode of audio-About 80% users appreciated the hint of audio, when it think scene before camera is too dark.	**Tutorial and Help** -About 92% users were of the opinion that there should be detailed tutorial and help user guidance

VI. Observations and Discussion

After using Talkback, the users suggested that there should be an option to create shortcut of Talkback, so that user can easily switch on/off by just clicking on desktop shortcut.

Moreover, some users also suggested that there should be a proper way to install application on their own and there should be a detailed tutorial at the startup of this application. It will definitely enhance accessibility of application. Users suggested that there should be more eyes free settings options to access all data.

User pointed out that web scripts is very slow, and it couldn't load automatically many times and they could not read offline html pages by using this application. Visually challenged people also preferred to improve the speed of roll screen of list.

As for the VizWiz iPhone application users faced different challenges regarding usability. User believed that there is need

to add more options and sources like Whatsapp etc. to improve response. User suggested that it should not depend on volunteer instead of I.Q database. They also highlighted that all icons should be clearly labeled so that visually challenged users can listen that what is going on. User suggested adding option to view supported currency reader and languages.

As from the findings we can clearly noticed that while using iPhone application visually challenged users face fewer problems of accessibility and usability as compared to android application.

A. Required Features for Smartphone Application:

TABLE IV
REQUIRED FEATURES FOR TALKBACK AND VIZWIZ

TalkBack	*VizWiz*
Lacking UI-About 98% users suggested that there is no proper interface of this application, user have to move around for several functions	**Video streaming-**About 84% user suggested having demand of video streaming option in this application
Installation and Launching – About 84% users suggested that the app should have a feature for installing and launching talkback to install it by themselves.	**Application's Database**- About 68% users suggested that application maintain data in its own memory so that it can match record with its own database when there is no internet availability
Accessibility shortcut- About 75% users think that it should allow users to create a shortcut for Talkback, so that can access it by quick action	**Supported Currencies-** About 98% users suggested that there should be option to check, the list of supported currency reader.
Big volume gesture- About 62% users suggested that there is need to add the talkback big volume gesture when calling.	**Friendly User Interface** – About 90% users suggested that the user interface requires a lot of improvement. There should be a main menu screen that should take user to various categories and options.
Speech feedback- About 72% users suggested that whenever using an audio stream which comes out both through the main speaker and headphones, should allow to hear the speech feedback.	**Enhance Option-** About 74% users suggested that there should be more functionality like video, text recognition etc.
Copy full of screen-About 65% users suggested that there is need to add a function to copy full of screen even full of document.	**Addition of sources-** About 68% users suggested that there should be option to add new source e.g. Whatsapp
Reading Interruption – About 94% users suggested that when the notification is pushed, it should not break off the reading process.	**Buttons labels-** About 96% users suggested that all buttons like back arrow, send button, Camera button etc. should be labeled, so that user can listen what is going on.

Based on the response of the users, we recommend a design for an ideal smartphone application for visually impaired users. The application shall comprise of the following:

1) A main menu screen containing the buttons for user section, log, support, about settings, categories and us.
2) User section should be password protected
3) The categories section should contain option to add source and delete source e.g. Facebook, Twitter, and Whatsapp etc.
4) Settings should contain option to create application shortcut
5) Log section should contain option to search image with recorded question
6) The interface should contain labeled buttons icons for moving back and forth.
7) Option to view supported languages and currencies.
8) Option to record video question.
9) Option to add text after image capturing.
10) There should be option to reply answer and save answer
11) Option to upload video question.
12) There should be option to "add focus lock"
13) There should be an audio tutorial to guide the users about the functionality of the application.

VII. PROPOSED APPLICATION DESIGN BASED ON ANALYSIS OF TALKBACK AND VIZWIZ

There are a number of features that are necessary for smartphone applications that are developed specially for blind people. During survey different participants provided us with several required features of smartphone application that are listed in Table IV.

The simplified block diagram that shows user end of new suggested smartphone application is shown in Fig 7. It illustrates the features of required smartphone application. Various controls and tabs are linked to show their flow and connection with each other.

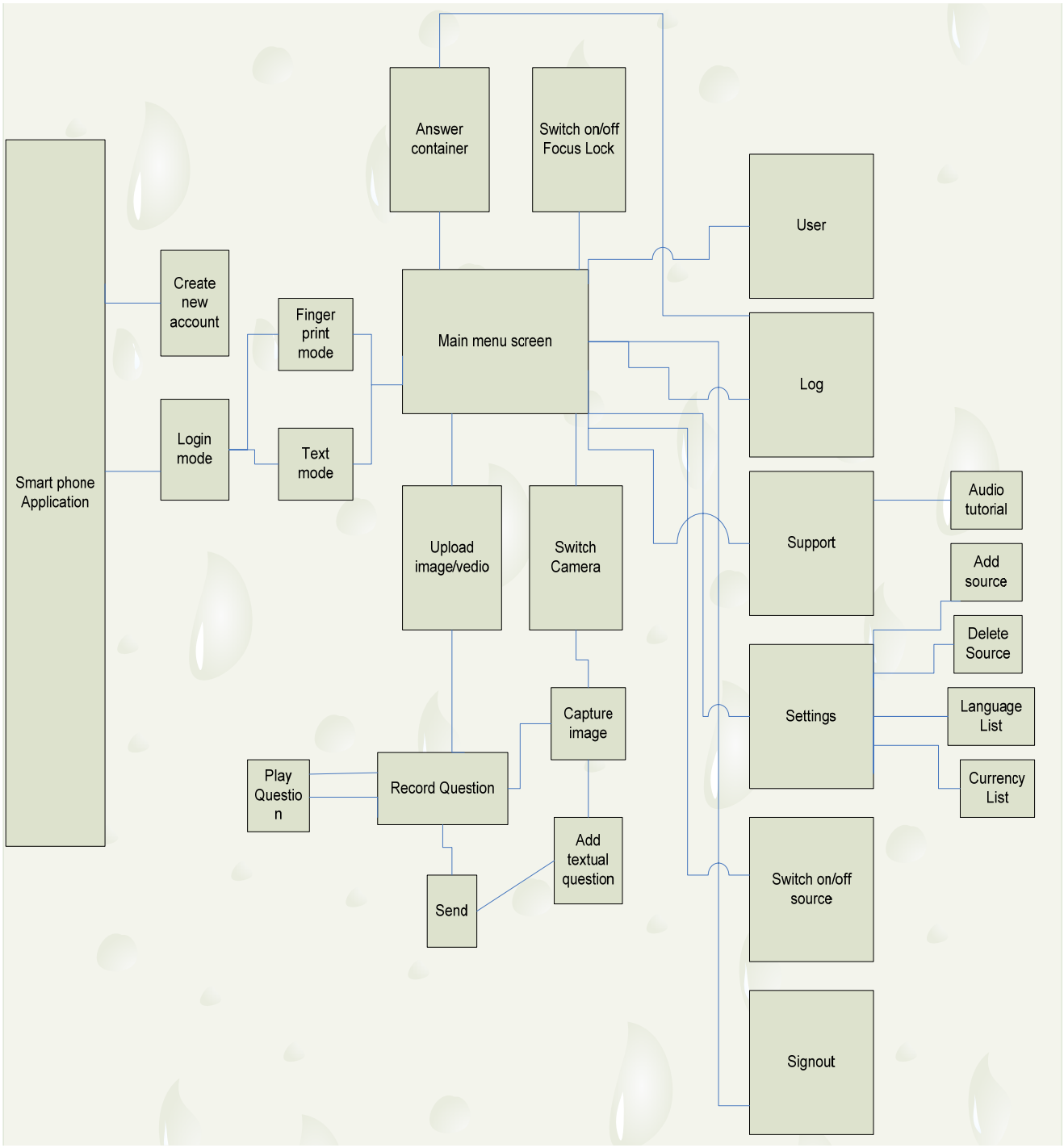

Fig. 7 Block diagram of new smartphone application

The application includes two different modes; fingerprint mode and text mode. Fingerprint mode will make the application more secure and easily accessible by registered users. Blind users can easily sign in to application by just swapping finger. To make application more secure, there is another mode that is text mode. By using text mode user have to authenticate him as an authorized user. Main menu screen of application contain different tabs and options such as add, source, focus lock, audio tutorial and many other categories as listed in suggestions. Text option is also added in design to, text their question instead of recording. There is also a video option to record a video and send it to different sources for getting answers within no minutes. Option of currency list will help the blind user to select the currency of their own choice,

and the application will recognize that currency. There is also an option to maintain history, either it is of recorded questions, answers or images. The source option, that will be switch on and off by user. There is a focus lock that will help the user to focus the image, it will be switch on and off on demand.

VIII. Conclusion and Future Work

Race in every field in the era of proliferation, confidential and liberalization, has pushed up the use of technology including smartphone applications. With the augmentation of technology and the popularization of smartphone, visually challenged people have the essential needs to disperse into the information age, make up physical shortcomings and enhance their learnability effects and efficiency by smartphones. The usability is very important to software; the results of this paper are also guideline for improving the usability and accessibility of smartphone application. This paper has analyzed two existing applications for visually challenged people and proposed a design for better application that can help blind users to carry out their routine tasks smoothly with the help of improved applications. The survey result shows that if application are user friendly and better in terms of usability, person with visual impairment would find easier to accomplish their daily routine tasks.

Acknowledgments

The authors acknowledge with gratitude the support and cooperation of those organizations and people who have participated in the study on smartphone's application. The invaluable facts and comments given by them are highly appreciated.

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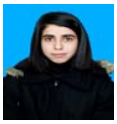

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Dr. Arif Raza received his M.Sc. (1994) in Computing Science from University of London (U.K.), and PhD (2011) in Software Engineering from the University of Western Ontario (Canada). During his professional career, he has been actively involved in teaching and research. Dr. Raza has authored and co-authored several research articles in peer reviewed journals and conference proceedings. His current research interests include usability issues in open source software (OSS), human computer interaction, human factors and empirical studies in software engineering. He is presently serving as Assistant Professor at University of Sciences and Technology, Pakistan.