ANALYSIS AND DESIGN OF REQUIREMENTS AND USABILITY ASPECTS IN ANDROID APPLICATIONS FOR VISUALLY IMPAIRED PERSONS

MCS

By

ANAM ASHRAF

A thesis Submitted to the Faculty of Computer Software Engineering Department, Military College of Signals, National University of Sciences and Technology, Rawalpindi, Pakistan in partial fulfillment of the requirements for the degree of MS in Computer Software Engineering

FEBRUARY 2015

SUPERVISOR CERTIFICATE

It is certified that the final copy of the MS thesis has been evaluated by me, found as per specified format and error free.

Dated: ____________________

____

Thesis Supervisor

Dr. Sarmad Sadik

ABSTRACT

ANALYSIS AND DESIGN OF USABILITY ASPECTS IN ANDROID APPLICATIONS FOR VISUALLY IMPAIRED PERSONS

By

ANAM ASHRAF

In this era of information and communication, technology has become indispensable for people with blindness. It is noticed that for visually challenged users, the progress has been much slower as compared to normal people. There are number of visually impaired users that require specific application that could help them in their daily lives.

User involvement is an important issue that is currently being researched and discussed in software development industry. Literature on software development reflects that user involvement in software development lifecycle (SDLC) process can contribute to software usability. Necessary considerations for improving accessibility and usability are generally lacking in software engineering procedures. Emergence of smartphones is an example of cutting edge technology. Usage of smartphones is equally important for people with visual impairment. Visually challenged people face numbers of problems while interacting with surroundings, because a variety of information is encoded visually. The research study propose a stepwise methodology for gathering requirements from visually impaired users and establish usability centered development model for visually challenged people. That helps to improve software development process. The proposed usability centered framework will be implemented by developing proof of concept based on a comparative analysis of smartphone applications and the requirements gathered from the case study to prove its effectiveness.

Moreover the simplified application is presented to enhance the usability and accessibility of application and also guide visually impaired people in order to identify the correct object by using their smartphone. The development was performed using the android platform and application was deployed on Samsung Galaxy Note II for testing.

Copyright © 2015 Anam Ashraf
All rights reserved

DEDICATION

In the name of Allah, the most Gracious, the Most Merciful. All praise to Allah almighty, for the strength, His blessings and mercy in completing this thesis. Guide us through the right path of those to whom you have bestowed your blessings.

This research work is dedicated to my beloved parents, friends, teachers and parents who had always been so kind, encouraging, loving and helpful. They always provided me with their utmost support in every field of my life. Their encouragement had been a great source of determination for me to achieve my goals in life.

DECLARATION

I hereby declare that this research, neither as a whole nor as a part has been copied out from any source. It is further declared that I have completed this work entirely on the basis of my personal efforts made under the sincere guidance of my supervisor. If any part of this project is proved to be copied out or found to be reported, I shall standby the consequences. No portion of the work presented in this project has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning.

ACKNOWLEDGMENTS

All praise to Almighty Allah, the most Merciful and Compassionate, Who enabled me to complete this project.

I express my gratitude to my supervisor Dr. Sarmad Sadik who kept my morale high by his suggestions and appreciation. Without his precious guidance and help I could never be able to complete this project. My special thanks to my thesis committee members: Assistant Professor Athar Mohsin Zaidi , Brig Fahim Arif and Lt.Col Muhammad Tayyab Ali for their encouragement and assistance in guiding me through the research and helping me improve the research work presented in this thesis. I also thank Dr. Arif Raza for giving his time and guidance during research work. I am thankful to my friends and family who were with me and encouraged me in the course studies. Special thanks to my all friend who accompanied me throughout my project.

And last but not the least; I would like to acknowledge the support of my family members. I would like to admit that i owe all my achievements to my truly, sincere and most loving parents and friends, who mean the most to me, and whose prayers are a source of determination for me.

Table of Contents

LIST OF FIGURES

LIST OF TABLE

CHAPTER 1

INTRODUCTION

Proper access to applications has emerged as an essential need for all kinds of groups in society. Numerous user studies suggest that the totally blind encounter more difficulty than those with other sensory disabilities (such as low vision, motor or hearing impairments) when performing specific tasks. 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 accessible user interface means that all potential technical restrictions have been eliminated, and thus anyone can easily interact with it. It is very essential to keep consideration of usability issues while designing an application, because as with the cutting edge of technology smartphone app usage is growing on rapidly. However currently there are number of smartphone applications e.g. android and IPhone applications that are not easily usable for visually challenged people because of different usability issues.

The smartphone usability basically involves the people, hardware and software to access information. Smartphones have also proven their fame among visually challenged users, which enthusiast us to concentrate on smartphone applications that are specially designed for visually challenged people.

At this time when technology is rapidly growing and people are using number of technologies to take benefits from them, it is very much essential to keep considering the usability issues. People access different services such as Facebook YouTube, Google etc. from their computers as well as from their pocket pc or mobile cellular phones. Usability inspection is quite important which is provided by different authorities.

It is applied by observing different behavior while using smartphone application or accessing web services accessed through different devices. Blind people use their mobile phones and other easy to carry devices to access all the computers applications and websites through wireless connection.

Usability controls is quite important which will be provided by different authorities and it will be provided by observing different movement on the websites and response towards behavior of user.

This work aims to optimize the usability of smartphone applications by implementing proposed usability centered development model and prove its effectiveness by developing new android application

1.1. Motivation

Numerous user studies suggest that the totally blind encounter more difficulty than those with other sensory disabilities (such as low vision, motor or hearing impairments) when performing specific tasks Furthermore, literature has shown that usability and its related issues have been a key area of research for electronic learning in general, and m-learning in particular [1] Usability has previously been less extensively covered than the technological aspects of the m-learning. Studies have also revealed that usability issues have a great impact on the success of mobile phone applications; however, there is a lack of research about learnability, understandability, ease of use, effectiveness, and efficiency of mobile applications—all aspects of usability [2]

Additionally, there are different life cycles such as waterfall, prototype etc. ensure that the system meets the needs of people without disabilities, the needs of people with disabilities are often overlooked thus resulting in systems that are inaccessible and unusable to them. The thought is to further enhances the avenues of its improvement by a community of volunteers and researchers Express' collective accessibility of applications by proposing user centered SDLC and provide a readily accessible tool that shall assist them in their daily routine tasks and be user-friendly for visually impaired people is the main motivation for selecting this topic.

1.2. Background

The vast growing technologies for blind users has attracted many researchers to get involved in developing and improving software and system applications useful for the blinds .

"Equalization of opportunities for disabled persons" is extremely low on the list of development priorities in Bangladesh and Pakistan. People may agree that it's a nice idea, but it is hardly ever a 'felt need' even among disabled people" [3].

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 [4].

Pakistan has 4.48 million people who are disable. Around two million people are completely blind in Pakistan. According to the "Pakistan National Blindness" visual impairment survey, reported that Punjab has 769,000, Sind has 200, 000, Khyber pakhtoon khawa (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[5] is shown in figure 1.1.

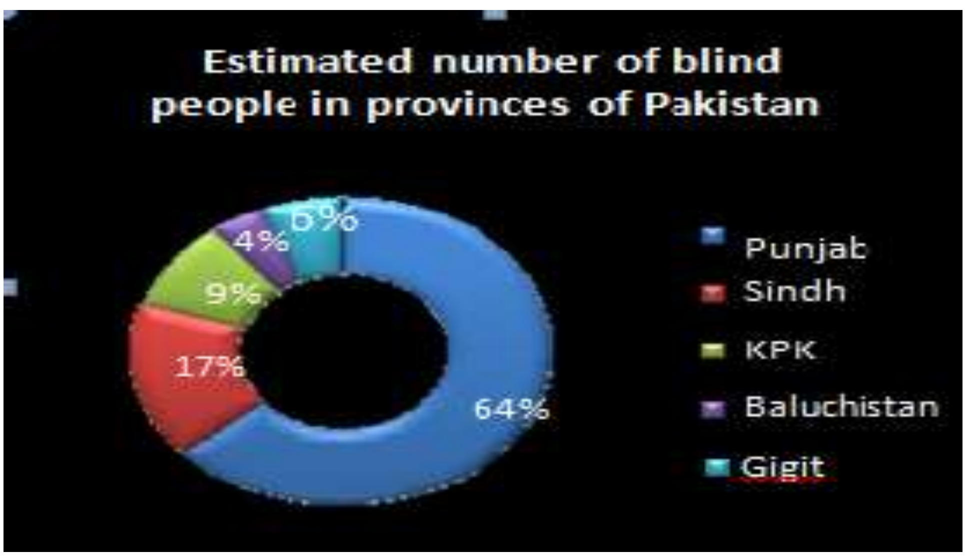


Figure 1.1 Estimated Rate of Blindness in the provinces of Pakistan

In [6], Une presented information presentation device foractive understanding to assist blind people. Imai, Tazawa [7] have developed touch screen application for the retrieval of speech information that help sighted people as well as visually impaired people.

"Ray" [8] 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 [8].

There are number of people who had done research in different areas for visually impaired people. In Pakistan, this is a relatively unbroached domain of research in software industry while students of special education at public sector universities have done studies concerning existing students with blindness at special institutes in specific cities and areas, but there is no standardized ratio.

1.3. Methodology

This work focuses on improvement of current implementation of android applications designed specifically for visually challenged people and its comparison with the original to analyze the performance gains.

1.4. Scope of Work

This application will provide an intuitive and interactive menu structure that allows the visually impaired to identify the things around them by capturing and sharing images for recognition. The captured images will then be identified by volunteer and also by Human Intelligent system and will get response with in few seconds in both audio and textual form and will be able to save in database the information associated with the captured images.

This work strictly focuses on the improvement of the current android applications from the perspective of usability. The existing and improved implementations are tested using established benchmarks for testing BEYOND VISON implementations from the several perspective of usability. The results of new vs. the old application are acquired by conducting and presented along with detailed graphs in Chapter 5.

1.5. Objectives and Problem Statement

The main aim of this work is to study and develop improved usability centered android application for visually challenged people to recognize the things around them by capturing image via their android phone.

The objective of this research include learning Android Software's Development Process/Cycle and test and evaluate the proposed BUSDLC implementation , performances analyses of the BUSDLC on deployed android application and finally to conduct usability analysis of the improved vs. existing android application.

1.6. Research Contributions

The major contributions of this work are to implement proposed BUSDLC model especially designed for visually challenged people to enhance the usability of android applications. The research work also enhanced collective primitives that outperform the existing implementations by taking lead from the existing research from the traditional SDLC implementations and enable visually challenged community to take full advantage of the enhanced version of SDLC . It will also enhance user confidence of the android application visually impaired users by indicating that it is an ongoing project with an active support community of visually challenged people.

Accordingly, this research contributes to this field in the following ways:

1. Creating a framework for improving blind user's involvement in software development model.
2. Designing, developing, and implementing android application for visually challenged people. This will be tested and evaluated by visually challenged users with smartphones.
3. Empirical evaluation, validation, and comparison of usability issues of the developed application.

1.7. Structure of the Thesis

This work is organized in various chapters. Chapter 2 provides detailed background and literature review related to this research; Chapter 3 elaborates the Blind User Software Development Life Cycle in detail along with the current implementations in android application .Chapter 4 gives details of the new implementation of Android application "**Beyond Vision"**;Chapter 5 provides the experimental results of the comparison between new and old android application of in a graphical format and Chapter 6 gives conclusion and suggests future work.

CHAPTER 2

2 LITERATURE REVIEW

2.1. Introduction

This chapter presents the literature review along with the existing applications developed specially for visually impaired persons. The main focus was to assess the Usability Centered development model for visually impaired people and the usability analysis of android application for visually impaired people. The next step was to start building the application which will help the visually impaired people to visualize the things around them. To do so, it was essential to study about the several applications designed for visually impaired people and various tools that could be used to develop the application.

In order to understand the current work, few important concepts like android development models and hardware, GCM (Google Cloud Messaging),Software development life cycle focus is on Google cloud messaging (GCM) and speech input. The subsequent discussion focuses on the approaches and mechanisms for usability analysis.

2.2. Human Factors and Software Engineering Lifecycle

The term quality seems self-explanatory in everyday usage, however in practice there are many different views of what it means and how it should be achieved as part of a software production process. For the correct development of application, development model plays a very important role. This paper has focused on how the traditional view of product quality in ISOAEC 9126 (1991) has been extended to include the needs of the user (ISOAEC 9126-1 and ISO/IEC 14598-1). Quality in use provides a link to the human factors approach to usability and to user end design.

Although usability has traditionally been associated with improving the user interface, the broader goal of quality in use is closely related to business requirements. It provides potential means for procurers to specify systems in a way which can give them greater confidence that the delivered system will meet their needs.

The human-centered design process in IS0 13407 describes a practical process which includes using mockups and prototypes to evaluate quality in use as the design progresses. There are four user centered design activities that need to take place at all stages during a project. “These are to: understand and specify the context of use, specify the user and organizational requirements, produce design solutions, evaluate designs against requirement”.

In this paper they define the relationship of quality in use to the other software quality characteristics depending on different types of users. They consider different categories of users (i) end user for whom quality in use is a result of functionality (ii) for whom quality in use is a result of maintainability (iii) for whom quality in use is a result of portability. In short the paper defines the activities necessary in the development lifecycle for achieving quality in use.[9]

2.2.1. Users’ Human Computer Interface Potential in Information System Development Life Cycle

In this life cycle [10], it is defined that, computer human interaction (CHI) capabilities are critical for successful systems development life cycle (SDLC) in order to manage information systems (IS) effectively. Insensitivities of IT acquirers towards end-users contribute to the gap between satisfying organizational needs, end-user deliveries and supporting organizational goals in the process. This problem can be addressed by carefully integrating end-user capabilities issues in the SDLC process to achieve a truly human-centered IS development. CHI capability management is a complex proposition and it is perhaps expected that acquiring organization should strategically plan these CHI capabilities. Software engineering process models provide tools to manage projects. Requirements elicitation and user involvement (CHI capability) are critical to success of an acquisition process. This acquisition process needs to be aligned with organizational processes.

In this paper a framework is suggested to capture CHI capabilities in an acquiring organization. The framework is tested for its fitness through structural equation modeling (SEM) with active participation from thirteen organizations. The usefulness of the proposed model is quite evident since it helps acquiring organization to assess its capabilities to manage user-led projects. The model is demonstrated through a case which is about its applicability in assessing the success of projects through a staged approach.

2.3.Involvement of Blind Users and Human Computer Interaction

Involvement of users in the software product life cycle is very well documented and it is generally recognized that the benefits of user participation are greatest at the start of the design process, however it decreases as the product pass through the several stages of life cycle. [11] User Centered Design [12], Usability Engineering [13] and Participatory Design [14] are usability methods that concentrate on user involvement in software development process. The importance of Human Computer Interaction, which force on usability, human-centeredness, use experience ,human factors, design issues, as well as concerns on the businesses success, organization and management have been accepted to some extent by practitioners [15]. Involvement of human factors in the earliest stages of the process ensures that a product is defined in terms of the user's requirements. Human factors embedded at these stages also help project management to redirect resources to implementation approaches. This is likely to have big benefit to users, when such changes are still relatively easy to make. Involvement throughout the process results in catching difficulties at the earliest moment, and so minimizes overall cost of project [16].

Blind User involvement is a process where blind users play their roles at every stage of software development process to produce usable software product that satisfies their needs in all respects. The role of blind user involvement can be scrutiny from different perspectives such as theoretical, pragmatic and political [16].

Using a user centered design working hand in hand with visually impaired people; a basic blind user interface is to be implemented. While interacting with computer, users usually used the existing mental model and when it comes to the new software, they will create a new mental model on how the system behaves. Mismatch between the existing mental models with the new system application create a problem for users.

The fast development of software has experimented over the last year. There are many possible reasons for this growing interest of technology: the diffusion of personal computing among a wide variety of users, the demands for more ergonomic computer systems, the need for reaching a top market etc. As a result, number of diverse methods, techniques and tools has been developed. Some of them can provide a huge fast and advance user interfaces design for people with disabilities [17].

For years, the main activity of people working in the area of rehabilitation technology was the adaptation of commercially available computers to the possibilities of users with disabilities. Assistive technology is "any application or device that is used to increase, maintain or improve physical ability or academic performance [18]". When the problem of gaining access to PC (Personal Computer) is solved the user faces another problem due the difficulties in using commercial software. Many applications have been designed without taking into account that they can be used by people using assistive technology [18] and therefore have unnecessary barriers for these users to overcome. Among the diverse interface design techniques developed within the HCI, the most promising are the ones that have to cope with non-standard interaction.

Olsson [19] in his study argues that *"we declare repeatedly that users should be involved in the design and development of computer systems, without questioning the reasons and motives behind this declaration".* Involvement of blind users in the software development and process has a major responsibility towards the outcome of the software product.

Human computer interaction is a discipline that emphasizes on the usability of software. Among the six characteristics of software quality which concerns on understandability, learnability, operability, attractiveness and compliance of the software system, usability is one of them.

2.4. Disability-Aware Software Engineering

Traditional software development has often followed set of approaches such as the various models of software development comprising waterfall, prototyping and spiral model. Each one of them has different phases and procedures for engineering software. Nevertheless, most of them are not adapted for disabled people. This is evidenced fact that much of the software developed today is still inaccessible to disabled people. This often arises from lack of consideration of the needs of disabled people during the software engineering process. Thus, vital considerations for improving accessibility and usability are lacking in the software engineering process. This paper aims to (i) propose a disability-aware approach to software engineering by incorporating accessibility and usability thus increasing the resulting software's accessibility and usability for disabled people, and (ii) to establish an evaluation method for the proposed model. In this paper, the author has presented a user sensitive inclusive design method for software engineering which ensures that the software meets the needs of disabled people, being both accessible and usable. To ensure the delivery of software that is of quality to disabled people, the author has established a disability-aware software engineering process model. Additionally, an evaluation method for the disability-aware software engineering model has been established too [20], [21].

2.5. Embedded Reading Device for Blind People: a User-Centered Design

Petters [22] addresses user centered design for blind people. Giving disabled people the greatest accessibility to their environment is the objective of CRETH, the Centre for Resources and Evaluation of Technologies adapted to the handicapped at the Department of Psychology of the University of Namur "FacultésUniversitaires Notre-Dame de la Paix" (FUNDP). For many years, a lot of centers for ergonomics and human factors developed theories and practical advice for the designers. Yet very often they are far away from the technical centers and their conclusions do not seem relevant enough to be taken into account in the technical design. In the case of disabled people, an insidious factor is added: people believe they know what is suitable or not for the handicapped people. The author describes the whole process to build an automatic text recognition system for the blind or visually impaired. The approaches that author have chosen aims at fostering the interaction between the software engineers and the end users in order to get a product adapted to the latter's needs. The system can be viewed as a main loop including the user taking the snapshot, Text/Picture detection, Optical character recognition, Text-to-speech synthesis, Feedback to the User, until a useful output is reached.

The interposition of a negotiator, a psychologist in this case, makes mutual understanding simple and easier and allows the suggestions expressed by the end user to be generalized.

2.6. Educational Computing and Visually Challenged People

Gupta [23] presents software engineering methodologies that are employed in developing educational solutions for the visually challenged people. The various design and learning requirements of educational products that are considered while designing applications for blind. Author discusses various development, deployment and testing issues too. The disabled sections of the society, who find it difficult to access computing devices, find themselves more marginalized due to this handicap [24].There are over 1.4 million visually challenged children below the age of 15 [25, 26], the development of educational technologies for the visually challenged people is a necessity of time. Imparting educational content and training to visually challenged students is a great challenge. Existing educational solutions assume visual ability, and hence are designed to be graphical and heavily based on human computer interaction (HCI) based on visual feedback from the system. Despite the availability of accessibility standards and screen readers, there are very few educational solutions designed keeping in mind the regional, cultural and educational background of the visually challenged [27].

From empirical studies and analysis, the author come to a conclusion, that the software solutions developed for the visually challenged community have a positive impact on the learning ability of the students. In the paper the author presents design, development and deployment of software for visually challenged people. The author highlights that *"during the course of the study, we were able to infer that rather than a universal design, a customized design based on the locality, culture, and the prevalent educational curriculum of the target audience is more feasible and able to meet the requirements of the users".*

The paper highlights the different technological and design challenges that were faced while developing and deploying the customized learning solutions.

Observations and results of the research point that there is indicative merit in developing and utilizing such applications for the educational consent of the blind. The study indicates that it will not only add value to the society through its empowering nature but also contribute extensively to the study of accessibility aspect of human computer interaction.

2.7. Improving Usability for Visually Impaired People

The importance of Web Accessibility has been stated by the World Wide Web Consortium that has raised the Web Accessibility Initiative (WAI) [28] in order to *"develop strategies, guidelines, and resources to help make the Web accessible to people with disabilities"*.

Some authors have analyzed and proposed specific design requirements to develop accessible web sites having a high level of usability for visually impaired people. Bolchini et al [30] discuss about problems and solutions related to the usability and accessibility of Web sites for people with visual disabilities and, in [29], they propose 14 different requirements to be taken into account by Web site designers and developers. Carmine [30] presents two different approaches for dynamically transforming Web Pages into Aural Web Pages. The first one approach is *"Auralisation approach"* that is based on the knowledge of the of the contents of a Web page and the second approach is *"Technique based on Structural Analysis"*. As there are no standard languages supporting the explicit definition of the semantic of Web page contents, so author adopt two different heuristic techniques: the former technique that is based on structural analysis of the HTML source code, and exploitation of semantic analysis of Web page contents. These techniques are used to extract relevant piece of information without any priori semantic knowledge.

Techniques and tools for the usability improvement of existing Web sites may be very useful. After performing experiment he noticed that the first technique tends to include in the auralised page only the text segments that are in the initial part of the document, while second is able to perform a better selection of the more relevant concepts. The main aim of author is to propose techniques to reduce the *"Reaching Time*" [31] needed by blind people while accessing web pages.

2.8. Basic Human Computer Interface for the Blind

Today, more than 6.5 million American's over age 65 have a severe visual impairment, often as the result of diseases such as age-related macular degeneration, glaucoma, and diabetic retinopathy.

Without intervention, the number of blind people worldwide could increase from 37 million in 2008 to 75 million by 2020 [32]. By 2030, medical experts and health officials predict that rates of vision loss and severe visual impairment in the United States will be double as America's 78 million aging people reach retirement age and beyond [33]. Of the 57,696 children who are legally blind, 10% (5,626) are registered with the American Printing House for the blind as Braille readers, 27% (15,303) as visual readers, 7% (3,942) as auditory readers, 34% (19,793) as non-readers, and 23% (13,032) as pre-readers [34]. It is a need of time to develop a human computer interface focus on usability for text to speech applications so that blind people can easily interpret the information. Raymond [35] chooses user centered design model so that the interface could be correctly designed according to the needs of blind people based on their heuristic interaction. The graphical user interfaces of modern operating systems have been improving usability at a good rate, but for blind users the progress has been a much slower rate if not declining. It is for this reason that the focus on accessibility should not be to interpret modern Graphical User Interface (GUI) but to develop an application based on the visually impaired people's general heuristic interaction with software.

The author proposes interface that provide basic interaction but is used independently from installation to task completion. Some of the applications that are used are: Non Visual Desktop Access, WebbIE web browser and accompanying apps, and Wikipedia and Project Gutenberg public domain free content. The application that is developed by author is in its pre-alpha stage and current user experience is being measured to improve usability and gain feedback for improvements.

2.9. Mental Model of Blind Users

There are number of visually impaired users that require specific application that could help them in their daily lives. While interacting with computer, users usually used the existing mental model and when it comes to the new software, they will create a new mental model on how the system behaves [36]. The main concern is to deeply understand how knowledge is transmitted to the human and show human interaction with computer [39, 40]. The goal of paper [37, 38] is to map the user's mental model and designer's mental model into the system image. Mostly problems arise when the designer developed system that does not meet user's mental model.

A good mental model allows a good interaction with the system and the most important is it can help improve system usability [41], [42].

The growing number of users with disabilities especially for blind users has attracted many researchers to cooperate with IT expert to develop various different technologies that will help visually impaired users in their daily lives tasks [43, 44, 45]. Both [46] and [47] have involved a domain expert in their work to gather expert's opinions and have deep insights in developing future application for the visually challenged people.

In proposing an improved version of a mental model for the blind, each stage in Kurniawan and Sutcliffe's model [48] was reviewed. It is envisaged that the model should be able to address the usability problem and able to help designer in designing better software for the target group. The proposed conceptual mental model has seven additional components from Kurniawan and Sutcliffe's mental model.

The components involve in the improved version of mental model are skill-based, knowledge-based, predict future event, domain expert, sighted user, system help, and select best alternative. These components are necessary in order to assist designers to minimize the gap between the developers' mental model and the blinds'. This study also showed that although users had already possess a mental model but a mismatch between the existing mental model with the new system application would create a problem for users. This paper also includes the need to get domain experts involvement in the design phase of the mental model proposed.

2.10. Visually Challenged and Smart Phone Applications

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 .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 [49]".*

According to National Eye Institute (NEI), in 2010 U.S. has 66% prevalent cases of blindness in female and 34% in male [50]. This is an evidenced fact that there are many software's developed today are still inaccessible to visually challenged people just because of their accessibility and usability issues. The usability is very important to software; the results of [51] are also guideline for improving the usability and accessibility of smartphone application. This paper has analyzed two existing applications Talk Back and VizWiz 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

2.11. Visually Impaired User Requirements Engineering

Blindness is a loss of sight and there are innumerable causes of blindness because of unusual performance of eyes knock on cognitive blooming. Multiple traditional practices and procedures are being used to guide people who are visually challenged. Developers and analysts have risen up with several creative and new ideas to assist visually challenged people to perform their routine tasks. As visually challenged people are unable to visualize world exactly so requirement engineers confront number of difficulties when eliciting needs of visually challenged people.

Frequent advancement in the terrain of smart phones i.e. androids and iPhone boost up investigators and analysts by deploying different applications to help them. Demands of requirements gathering of cellular applications specially developed for visually challenged persons are focused in this paper. As the visually impaired people facing slightness problems so they become unable to explore their daily transformations and hesitate to get their jobs done. Requirement elicitation of blind users is quite expensive and difficult. In [52] highlights the pick and shovel faced by the visually impaired community and contains VIURE (Visually Impaired User Requirements Engineering), a technique for eliciting needs from visually impaired people. VIURE has three impersonal that are, intruding recruitment, data gathering with the help of descriptive rescue objects, and adaptation to performing flashback boundary among visually impaired. VIURE in the eventual can be used for eliciting needs and needs from multiple people talking different disabilities.

2.12. Usability Assessment of TapTapSee and VizWiz

The apps that we have analyzed for this study are from android and IPhone domain. The android app under analysis is:

A. *TapTapSee*

TapTapSee is a mobile camera app to help visually challenged people to fulfill their fundamental desires and requirements. It is a simple application with three buttons on screen to facilitate visually impaired users to capture and recognize image.

Figure 2.1.Screenshot of TapTapSee

The IPhone application that we are analyzing is:

B. VizWiz

VizWiz is designed by "Rochester Human Computer Interaction" to help visually challenged people 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 answers.

Figure 2.2.Screenshot of TapTapSee

The main purpose of both the application is to facilitate the visually impaired people to locate things. The achievements mentioned above had a very positive impact on visually challenged people's routine life. On the other hand, they could become inconvenient due to less user interaction and complex hardware systems. We have performed the analysis of existing application, TapTapSee and VizWiz by conducting open ended question survey and asked the 82 visually impaired users to highlight the pros and cons of these applications. The results for TapTapSee and VizWiz are summarized in the following section

a. Pros of TapTapSee

TapTapSee comprises of the following pros

- Users appreciated the application layout, that application user interface is appealing
- Users were of the opinion that if the features are address properly, this application could be helpful for visually impaired.
- User found easy to navigate, to search respective items placed on screen.

b. Cons of TapTapSee

Cons of TapTapSee are listed as:-

- **Limited features-**the classification of features should be broader enough to facilitate users such as search bar, History etc.
- **Unable to repeat all results:** User can only repeat the most recent result not all.
- **Unclear answers:** often provide unclear answers about object identification
- **Audio functionality:** Users identified that audio functionality like question recording is missing in application.
- **Lack of Help:** Users found that audio tutorial guide is missing in application.

c. Pros of VizWiz

The pros of VizWiz are listed as:-

- **Tweeting Question:** Users appreciated option of tweeting your question via Twitter
- **Web Workers:** Users found web worker option of app as the most effective.
- **Multiple response:** User appreciated the multiple response of various questions
- **Efficient Response:** Users were of the opinion the application response time is good enough.

d. Cons of VizWiz

Cons of VizWiz are listed as:-

- **Confusing Interface:** Users were of the opinion that interface is quite confusing for novice user
- **Vague Interface:** The buttons should be properly labeled to enhance its usability such as back button, search button, microphone button camera button etc.
- **Camera icon:** found difficulty to tap camera because of its improper placement.
- **Similarity of Icons:** Unable to identify the buttons that which one is for question sending and which one is to repeat question.
- **Notification Issue:** Unable to get notification alert on performing functionality at the same time.
- **Improper Functionality:** Search icon perform the functionality to upload the image from gallery, it should be for searching specific data or image from history.
- **Inactive labels:** Labels in "Select Sources" menu such as twitter, Web workers etc. are found inactive and they are not readable by Voiceover. And users become unaware of that what's going on.
- **History Menu:** Unable to listen the answers once it gets stored in history menu and even not readable by voiceover.
- **Misguiding Menu text:** On taking picture application asked user to record a question, but unable to record until we clicked on microphone button.
- **Lack of usability:** Users found that application has several usability issues such as confusing interface etc.
- **Lack of built in audio guidance:** Users are unable to listen most of the actions even using Voiceover such as image has been captured, start recording, recording finished etc.
- **Internet Connectivity:** Application does not provide notification on unavailability of network connection.

The above-mentioned potential inconvenience was our major motivation and focused in order to design and develop a competitive application based, as much as possible, on simplicity and user-friendliness and handling the usability issues and cost as well.

2.13. Summary

Chapter 2 begins with concept of Software Development Life Cycle along with Disability aware software engineering followed by HCI. The importance of human involvement including visually impaired people is also explained. The usability and design issues of smartphone apps are also discussed. The chapter concludes with a focus on Requirements elicitations and usability of smartphone applications for visually challenged people, which is the main focus of this work.

CHAPTER 3

3 METHODOLOGY

3.1. Introduction

This chapter covers the methodology adopted in this work. It includes the study of a novel framework for improving usability of applications and focus of blind user's involvement in the whole process of development. A stepwise methodology is presented for gathering requirements from visually impaired users and establishes usability centered development model for visually challenged people.

That helps to improve software development process. The measuring major usability aspects of smartphone application design and propose an android application to support the proposal usability centered framework.

This support is provided in a form of technical survey that has been conducted by two different organizations of Pakistan, Pakistan Foundation Fighting for Blindness (PFFB) and National Institute of Electronics (NIE) and visually impaired users at Beijing China.

Figure 3.1 shows our research plan we have used to design, develop, implement, test and evaluate our android application for visually challenged people.

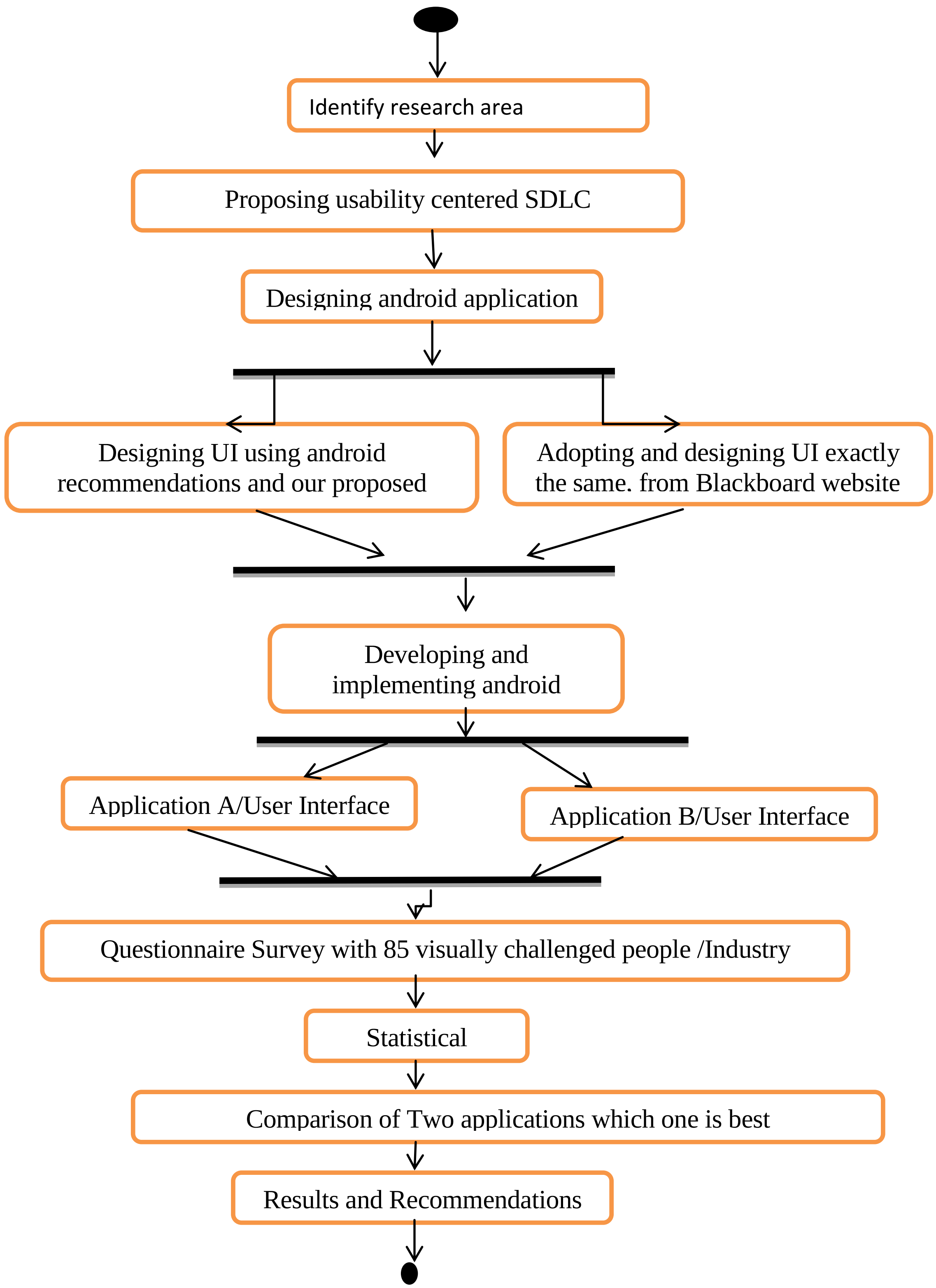


Figure 3.1: Research Methodology View

3.2. Design Specification

3.2.1. System Block Diagram

Based on the response of the participants [53], 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) Built in option to read out the options where the user moves.
3) User section should be password protected
4) The categories section should contain option to add source and delete source e.g. Facebook, Twitter, and Whatsapp etc.
5) Log section should contain option to search image
6) The interface should contain labeled buttons icons for moving back and forth.
7) Option to record audio question.
8) Option to add text after image capturing.
9) There should be option to reply answer and save answer
10) Option to upload video question.
11) There should be an audio tutorial to guide the users about the functionality of the application.

The simplified block diagram that shows user end of new suggested smartphone application is shown in Fig 3.2. It illustrates the features of required smartphone application. Various controls and tabs are linked to show their flow and connection with each other.

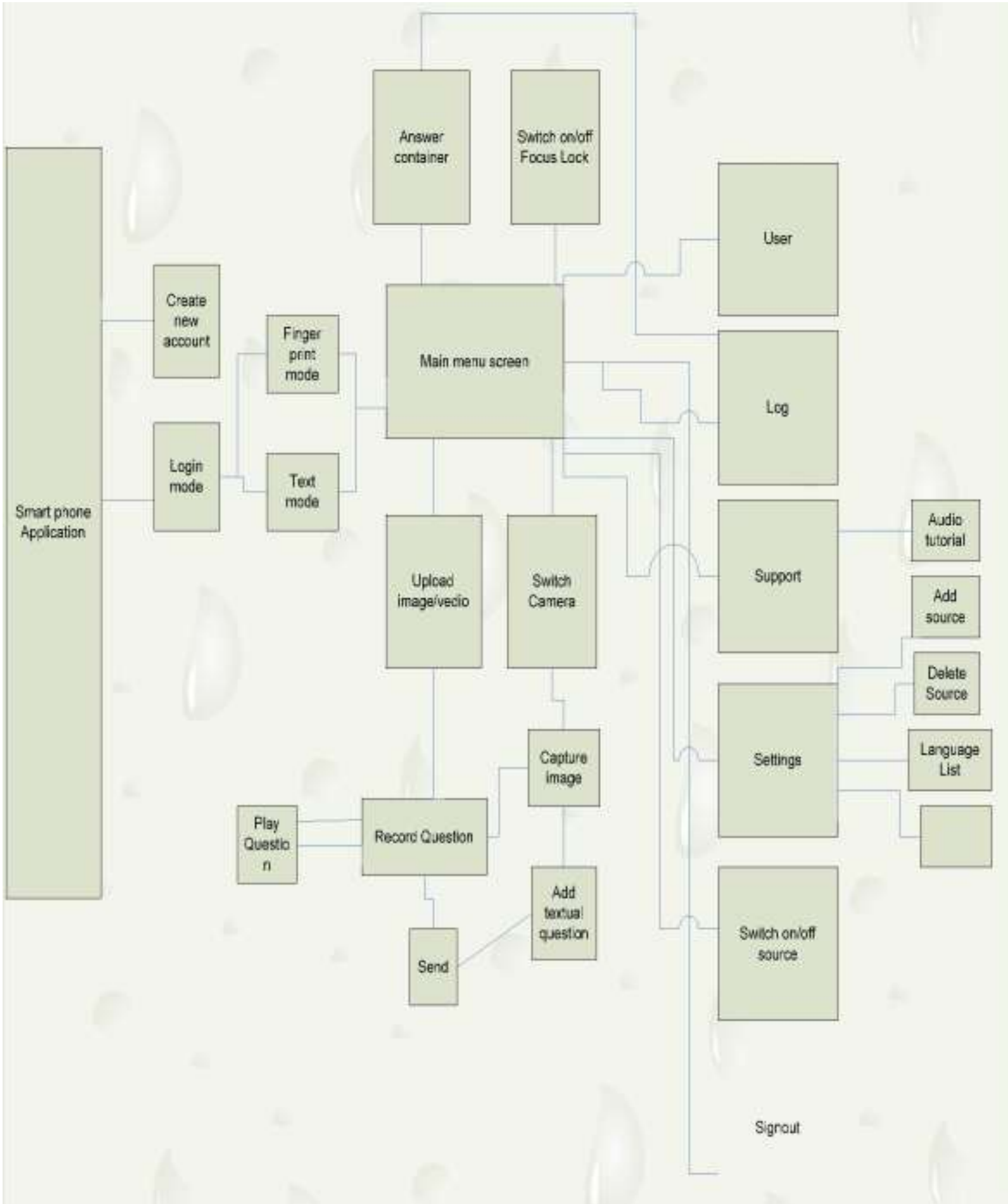


Figure 3.2: System Block Diagram

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.

3.3. System Requirements:

Following hardware and software requirements are used for the development.

3.4. Hardware Requirements:

- Mobile Phone Having Android as OS
- minimum 3 Megapixels Camera

3.5. Software Requirements:

- Android Software Development Kit (SDK)
- Eclipse Integrated Development Environment(IDE)
- Java SDK 1.6
- Java HTML Parser (JSOUP)

3.6. Proposed Framework Blind User's Software Development Life Cycle (BUSDLC)

Figure 3.3 shows the proposed blind user SDLC to improve development of software product for user with special need of blindness

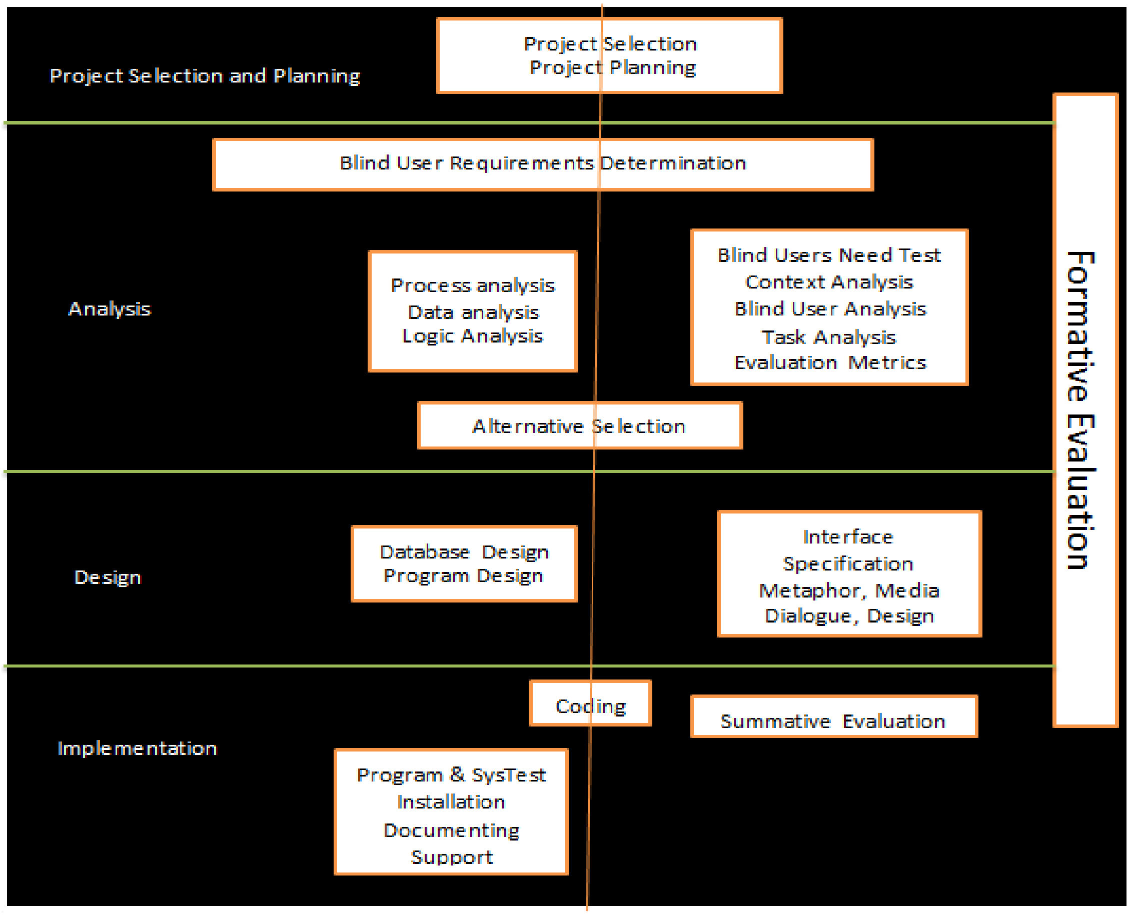


Figure 3.3: Proposed BUSDLC

It indicates how blind users are involved in different phases of blind users' software development life cycle. The multiple phases mentioned in the BUSDLC are selection of project and project planning, software analysis, software design and finally the implementation. Once the project selection and planning phase is complete, the proposed model moves onto the **analysis phase**. In this phase, unlike the traditional SDLC, the requirements are gathered along with the major stakeholder i.e. blind users themselves.

Since the blind users are part of the requirements gathering process, they are there to correct the requirements engineer if he is going in the wrong direction. After this the usual process, data and logic analysis is carried out like in traditional SDLC. Henceforth, the blind user is once again consulted to review the analysis phase. Here the blind users carry out the blind users need test, context analysis, blind user analysis and task analysis. This results in the formulation of the evaluation metrics. If the evaluation is successful, we onto the next phase otherwise alternative selection, i.e. repeating the whole analysis phase is carried out. Next we move onto the **design phase**. Here the database design and the program design are formulated as per the traditional SDLC

After this, the opinion blind users are again sought after to ensure that the interface specific metaphor, media dialogue and hence the design are all suitable to be used by the blind users. In case there is some ambiguity, the design is restructured until it is fit for the stakeholder's use. The next and the final phase is the **implementation phase**. Here the actual coding of the app is carried out. The blind users periodically consulted to ensure that the coding and the hence, the final product is fit for their use. Once the coding is complete and the blind users have given a green signal, summative evaluation is carried out. After this, quality assurance techniques are carried out to conduct the program and system test installation. This and followed by the application documentation finally the system support is ensured.

In traditional development model users didn't appear to be heavily involved throughout the development phases. Traditional development approach leaves the main responsibility for analyzing requirements and designing the appropriate system to the software development staff. While proposed model keeps participation of blind users throughout the development to develop more usable system for blind users. The approach used in BUSDLC is the adoption of human computer interaction, to improve the participation of blind user.

3.7. Understanding the blind user's cognition and behavior

It is our contention that understanding the nature of accessibility and usability problems of visually challenged users requires examination of their cognitions and behavior during application interaction. Application interaction, like other human behavior, involves three types of basic processes: perception, cognition, and action. Problems occurs when application demands extra physical or mental effort

3.7.1. Seven Stages of Action

Norman [54] proposed the seven-staged action model to explain the interaction process between a user and a system, and identify conditions that give rise to usability problems. He emphasizes the need to understand the perception, cognition, and motor functions of a user during interaction. This approximate psychological model that is very much important to consider when developing application for visually challenged people and it accounts for both cognitive and physical activities.

Norman's model characterizes the complete interaction process between a user and a system into seven stages that we considered while catering usability issues of android application designed for visually challenged people.

1. **Goal identification**: The interaction begins with the visually challenged user identifying the outcome of the task.

2. . **Intention**: Once the visually challenged user identifies a goal, the next step is to form an intention of accomplishing the goal

3. **Plan of action**: To translate the intention into action, the visually challenged user identifies an action sequence or series of steps leading to the goal.

4. **Execution**: The visually challenged user will execute the planned action by physically interacting with the application

5. **Perceive system response**: After executing an action, the visually challenged user perceives a change in system state. A visually challenged user perceives system

response aurally based on an announcement made by the screen-reader. For instance, the user will detect a new page only if the screen-reader provides some kind of audio feedback.

6. **Interpret the results**: After perceiving the system's response, the visually challenged user will try to make sense of its meaning with respect to the goal.

7. **Goal accomplishment**: Based on her interpretation, the visually challenged user will decide if he/she has succeeded in accomplishing the intended goal.

The most insightful aspect of the seven-stage action model is its ability to identify sources of problem during user-system interaction.

3.8. Criteria for Accessibility and Usability Evaluation

We will adopt an integrated set of usability criteria for evaluation of an android application designed specifically for visually challenged people.

3.8.1. Neilson Usability Criteria [54]

1. **Learnability:** If first-time users can become productive quickly in terms of finding information and using functionality on the application

2. **Efficiency:** If users can accomplish tasks quickly, without much cognitive effort, after learning the application

3. **Errors:** If users are prone to committing errors, and if they recover quickly.

4. **Satisfaction:** If users are satisfied with how the application works.

5. **Memorability:** If returning users have to relearn how to use the application

3.8.2. Norman Principles of Good Design [55]

6. Visibility: If users can tell what is going on with the system, and derive alternatives for action by observation.

7. Good mappings: If users can determine the relationships between actions and results, between the controls and their effects, and between the system state and what is visible.

8. Feedback: If users receive full and continuous feedback about the results of actions.

3.8.3. Shneiderman and Plaisant, Rules for Interface Design [56]

9. Consistency: If the sequence of action is consistent in similar situations; if labeling, order and effects of user interface elements are consistent.

10. Working memory load: If displays are kept simple, multiple page displays are consolidated, and window-motion frequency is reduced. We adopt and apply these principles to study the accessibility and usability problems that visually challenged users face in application interaction. They provide a basis for us to understand the cognition and behavior of visually challenged users and characterize the nature of problems that they face in smartphone application interaction.

3.9. Development and Debugging Environment

Eclipse platform provides the necessary tools and support required for either development of applications as well as modifying and enhancement. Being a familiar tool for Java developer

community, it is used for the later. The environment setup is done using the guides available at the official website of android application development.

3.10. Involvement of visually challenged Community for Testing

The smartphone app user interface (UI) has used heuristic evaluation as a technique to measure usability factors. Heuristic evaluation is an engineering method for easy, quick, and cheap evaluation of a user interface design [57]. It is known as one of the most popular usability inspection methods, and it is done as a systematic inspection of user interface design for usability [57].

Furthermore, we have made the involvement of visually challenged communities around the Pakistan and China to test the application at each stage of development to improve usability of application better.

As mentioned, a usability questionnaire was conducted to evaluate the usability issues of the android application among 85 visually challenged people. However, using this technique and by giving the participants real android smartphone devices, participants could use this application to share opinions regarding their experiences while interacting with the real application. Participants rated each question from 1 to 5 on a Likert scale (1=very easy, 5=very difficult), see Appendix A.Upon collecting the data, we investigated the level of usability by evaluating the application's user interfaces, which include ease of use, user satisfaction, and attractiveness and learnability. A comparison has been done to determine the most user-friendly interface that our application consists of (see chapter 6).
In addition to the design application, we have created a framework for improving usability of application development, which we have used as a guideline while designing and developing our application (presented and discussed in chapter 4).

3.11. Performance Evaluation of Proposed Framework and New Application Design

Finally, we come up with the fine-tuned framework and android application with various functionality. To test the new application operations, various benchmarks including usability matrices are used. The detailed analysis and discussions is given in Chapter 5, Results and Discussion.

3.12. Summary

Chapter 3 elaborates the broad overview of the methodology adopted during the course of this research. It begins with introduction of blind's user cognition and behavior followed by three different criteria for accessibility and usability evaluation, deployment and debugging environment for android application, running applications on android platform and subsequent testing and evaluation of the application by involving visually challenged community.

CHAPTER 4

4 IMPLIMENTATION

4.1. Introduction:

Implementation contains all details which are required to make the system operational. I have also discussed the development tools and technologies to implement the system. And all the functionality implemented in the project is described in details.

4.2. Tools and Techniques:

The software required for the development of this project are Java, XML and Eclipse. They contain the features that are capable of meeting the requirements of the proposed system.

4.3. Description:

This framework and application is created for the improvement of usability centered development model for the visually challenged people. To make the application unique is the fact that application is designed to tackle the usability issues of visually challenged people. When the application starts, it will first get the data from user via internet connectivity. Then server will authenticate it and will get back to user with response.

4.4. System Overview

We propose an object identification system "Beyond Vision" to recognize object by visually challenged people. Human visually system use different structures and patterns to locate and assist the people in moving around and to detect objects. We design a system which is similar to human visual system with audio control system to guide user and provides the visually challenged people with the information about their captured image.

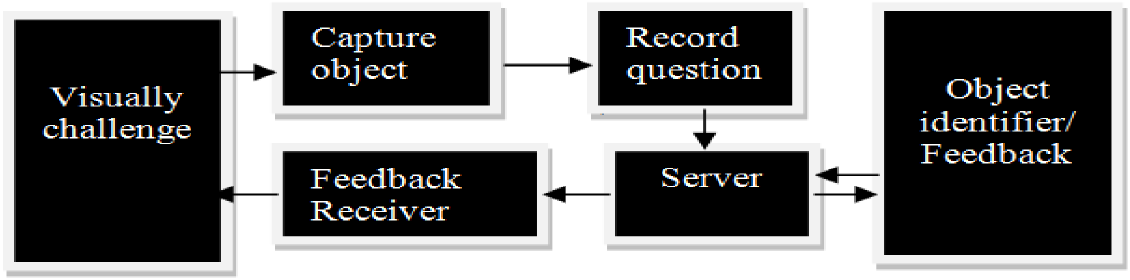


Figure 4.1: Block Diagram illustrating main steps of object identification algorithm

Our designed object identification system consists of different blocks, which are shown in figure 4.1. The main blocks are discussed in detail in subsequent sections.

4.4.1. Capture Image

One of the most important steps in this application is to capture the correct image by visually challenged person and it is surely done by using technique of auto camera focus.

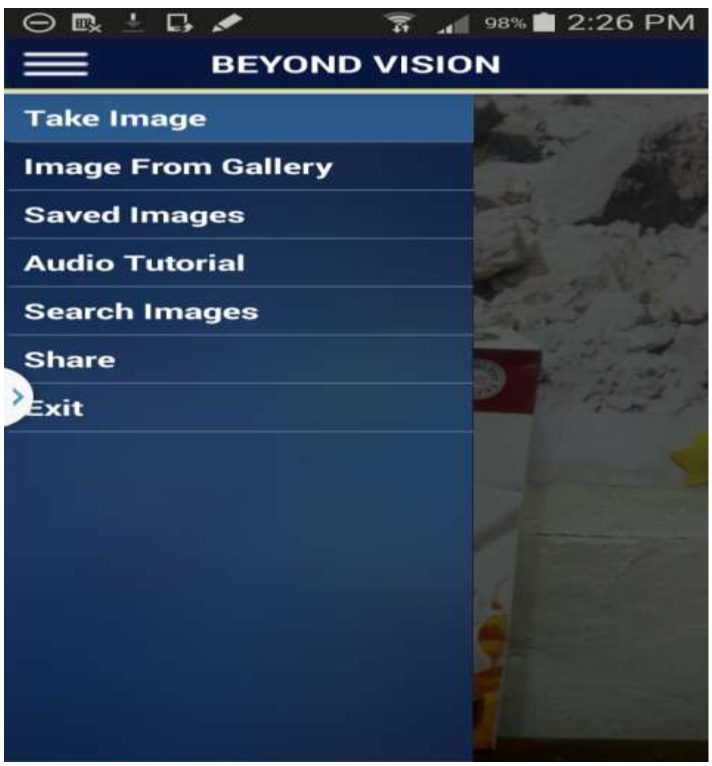


Figure 4.2: Image capturing

We embedded the functionality of auto focus this will assist the visually challenged people to focus the object and capture the required image by just taping anywhere on the screen of smartphone.

4.4.2. Record Question

Record question process is also a trivial part of a system. By using this feature user will be able to record audio question by just taping the captured image screen and will tap again to send it to the server to get feedback.

Figure 4.3: Record question

This option is very much necessary for visually challenged people. In the previously developed application [58] there is no option to record question of visually challenged person and the app [59] having this option, placed the microphone button that is very much difficult for visually impaired to find out where it is on the screen. Because of this, past application cause problem for user. To enhance the usability of designed application this and many other sub functionalities are beekeeping ease of accessibility and usability in mind \

4.4.3. Object Identifier/Feedback Provider

After capturing image and question recording server pass the message via Google Cloud Messaging (GCM) service to the object identifier who are the volunteers .The number of volunteer are able to receive the image with recorded question, after listening to that question feedback answer will be passed back to server and the server will pass the first received feedback to the feedback receiver.

Figure 4.4: Object Identifier

4.4.4. Feedback Receiver

Then the provided feedback will be received successfully within 20 seconds to visually challenged person .and he will be able to listen that feedback about captured image and can also replay the answer by tapping the screen.

There are many other required features in “Beyond Vision” application such as “audio tutorial” to guide visually impaired users, built-in “Talkback” service to read out loud what’s going on, “Saved images” menu that contained all the captured images with tags and they are readable on tapping the image. “Search” option is also there to search any saved image with tag.

This application is basically solving the issue of color identification and image detection as well by just recording question what he want to know and get their required answer within no minute.

Figure 4.5: Feedback Receiver

5 Results and Discussions

The application is designed by following proposed framework "BUSDLC" and gets the evaluation result of proposed framework by survey of different industry experts.

5.1. Validation of proposed framework by experts

Proposed BUSDLC was validated by questionnaire survey. Different experts rated it according to their experience in industry as shown in Table 1.

Table 1. Validation of BUSDLC by experts

Questions	Strongly Agree	Agree	Strongly Disagree	Disagree	Neutral
BUSDLC shows that participation of blind users that is very much important in all phases of system development	95%	81%	12%	10%	0
Proposed model BUSDLC is good enough to implement in industry	75%	84%	23%	5%	0
BUSDLC has no use at all in industry	9%	16%	87%	94%	0
Proposed model focus on organizational need as well as on blind users' needs	96%	81%	17%	4%	0
BUSDLC has more focus on usability and user interaction rather than organizational need that is positive.	83%	77%	5%	2%	0
HCI is addressed in proposed model, will enhance system usability	87%	69%	32%	29%	4 %

The response indicates that participation of visually challenged users is very much important while designing an application specifically for them. Results also shows that the concern of usability and human interaction matters a lot in the development phases, as it definitely enhance the system usability.

5.2. Testing and Evaluation of application "Beyond Vision"

We also conducted lab based user study of "Beyond Vision", "TapTapSee" and VizWiz application in which we asked visually impaired users to identify Orange Cup placed on table having different cups as shown in figure 5.1. For this study we recruit 82 participant who were visually challenged .On the first, we deliver a trial demonstration of applications on android smartphones and trained them for 15 minutes. Then we asked them to use both applications one by one and identify item.

Figure 5.1: Cups placed on table

Figure 5.2: TapTapSee **Figure 5.3: VizWiz** **Figure 5.4: BEYOND VISION**

For the purposes of this study, researchers concentrate on the user interaction with the applications, although our experience has been that volunteers of Beyond Vision app can quickly answer questions requiring them to outline items. For all five trials, visually impaired participants started capturing images and they took clear and blurred images too and cups were randomized after each trial.

5.3. Evaluation and Results

Visually impaired participants used both applications to locate specific “orange colored cup” out of six different cups. Beyond Vision enable the users to identify the correct cup by asking question to identify the specific cup. But as far as TapTapSee and VizWiz is concerned it provided with answer as “Black ceramic mug”, “Painted cups on table” respectively and became unable to identify the specific orange one because of limitation of application. The time required for each application was same, and TapTapSee response time is 40 seconds where “Beyond Vision” response time is 20 seconds that is ideal for visually impaired user. And more than that, user can also listen the response tags of the captured images any time by visiting “Saved Images” menu and can share their captured image on social network like twitter, Facebook; Whatsapp etc. screen shots of complete application “Beyond Vision” is attached as Annex A.

After the completion of testing of apps, we performed a survey to know on spot about different usability aspects of applications “TaptapSee” VizWiz and “Beyond Vision”.The questionnaire were having twenty one questions based on Likert-scale (strongly disagree, disagree, agree, strongly agree, neutral,) and we come up with results as shown in figures below.

The figure-5.5 shows that understanding the functionality of BEYOND VISION was very easy to learn for the users. About 52% of the users were thinking that they did not find the overall learning of the application very difficult.

However, on the contrary the TapTapSee and VizWiz were not very easy to learn for the users. About 35% and 46 % of the users were of the opinion that they found the over learning of the application’s functionality very difficult.

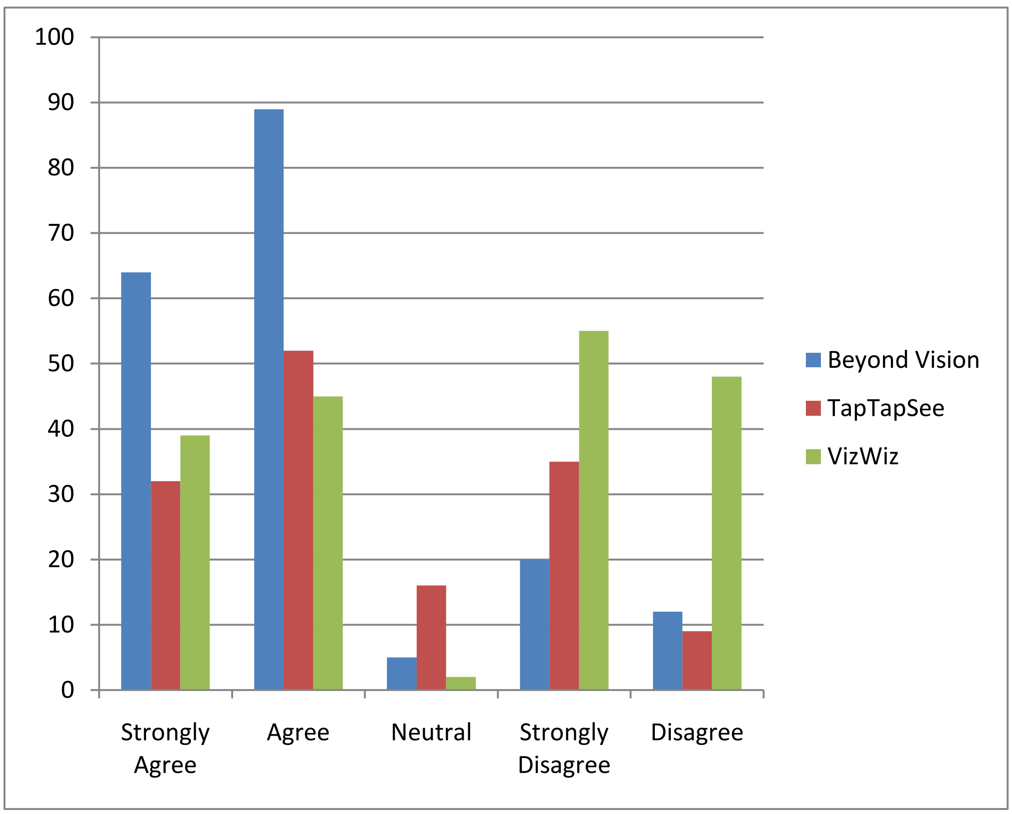


Figure 5.5: Ease of learning

The figure-5.6 shows the user opinion regarding efficiency of the applications. The 83% users of BEYOND VISION were of the opinion that application is more efficient as compared to already existing application TapTapSee and VizWiz. The user results clearly show that TapTapSee and VizWiz application efficiency was low as compared to BEYOND VISION. About 17% of the users have voted against the application BEYOND VISION.

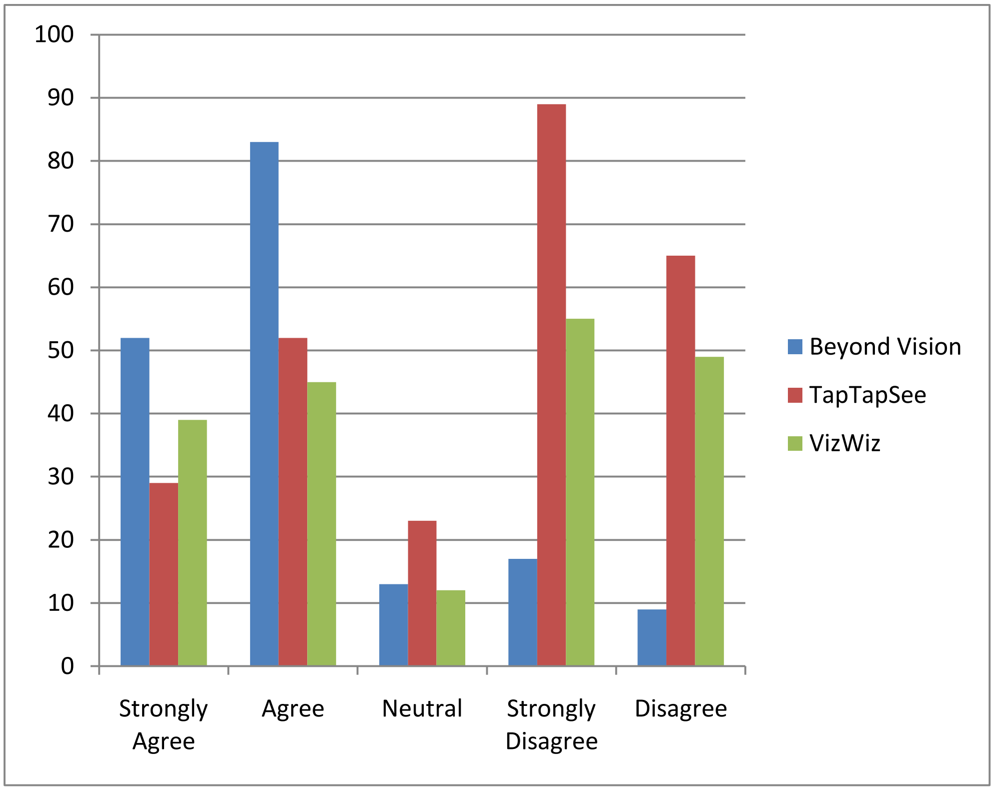


Figure 5.6: Efficient to perform

The figure-5.7shows that there is no proper design in case of TapTapSee and VizWiz. 20% of BEYOND VISION users, 59% of TapTapSee users 32% of the VizWiz users were of the opinion that there is lacking usability and that is why design is not completely accessible to visually challenged people when interacting with application.

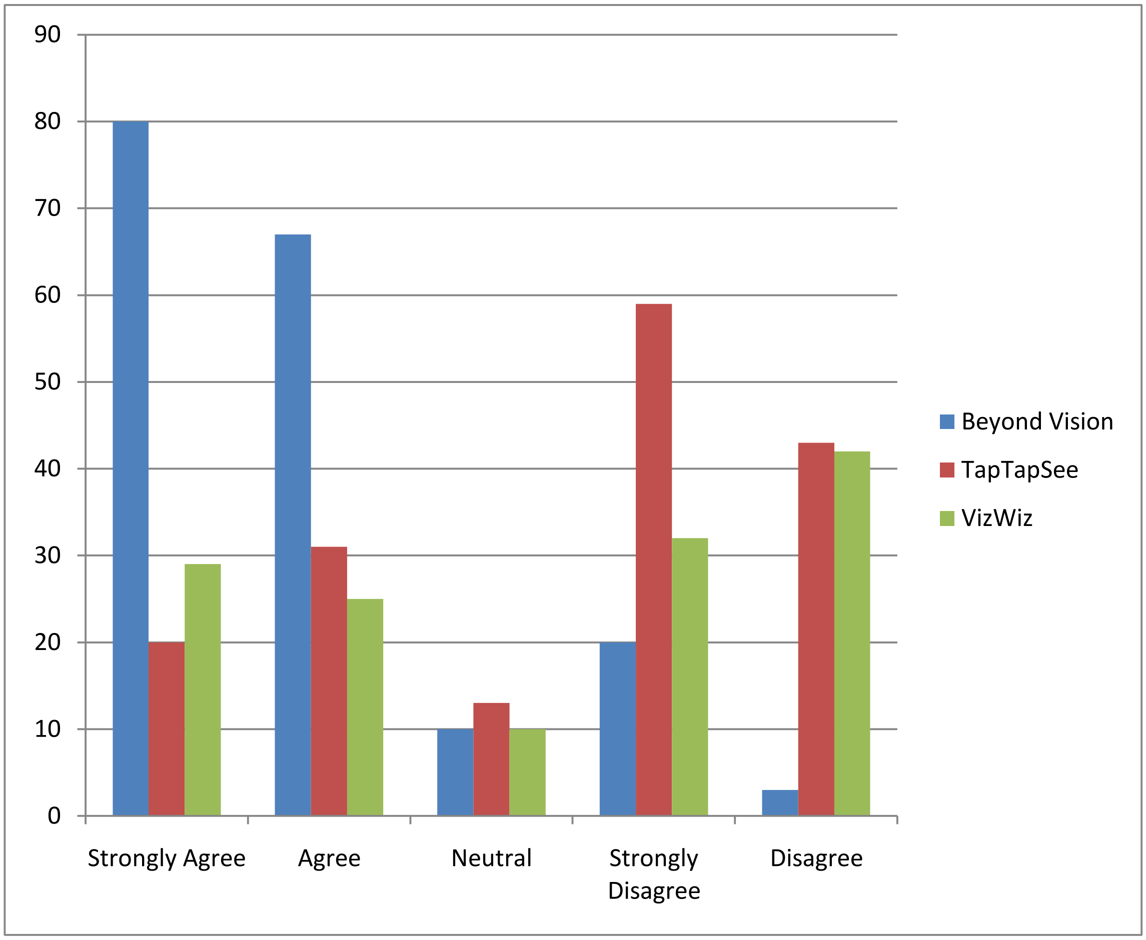


Figure 5.7: Accessible design

The figure-5.8 shows that 86% and 62% user didn't found a proper channel of recovery from errors while interacting with TapTapSee and VizWiz respectivly.While 21% users found lacking of error recovery in BEYOND VISION. Infact feedback is the important part of usability that was lacking in applications.

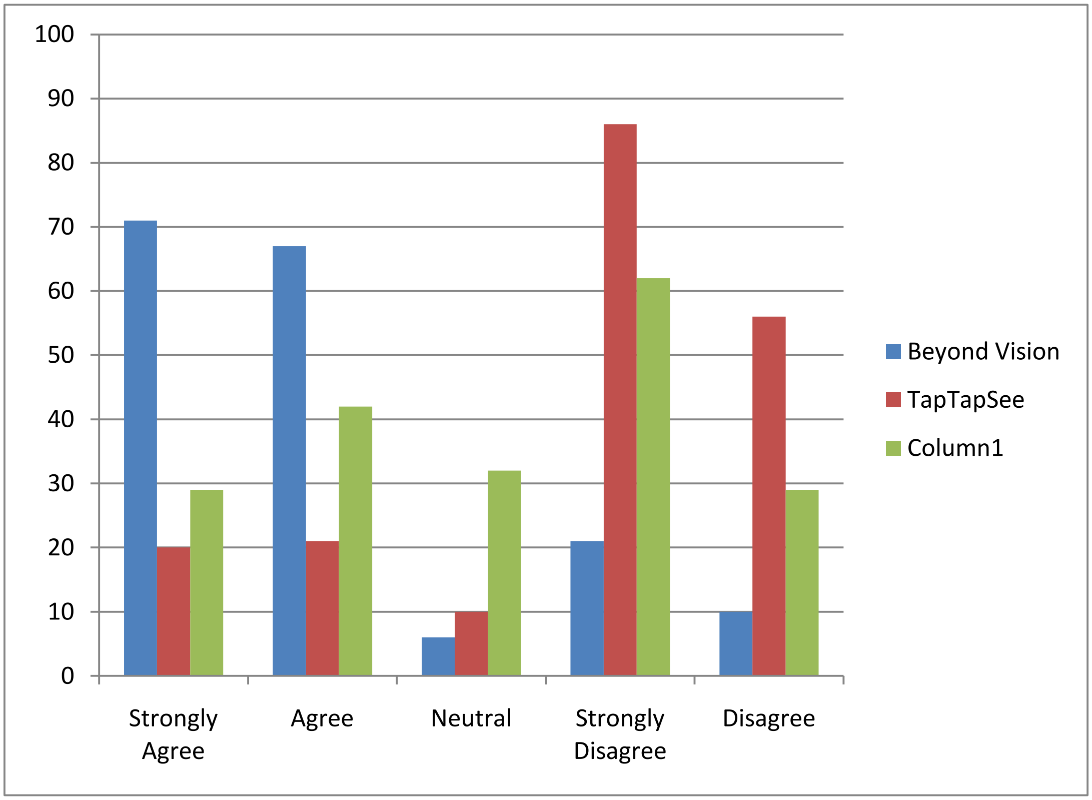


Figure 5.8: Good feedback

The figure-5.9 shows the user response when asked about help and guidance provided while interacting with the applications .This was to assess whether the application provided enough guidance. The results below shows that 92% of the users were of the opinion that BEYOND VISION is doing too good in this respect as providing help and guidance in the form of audio tutorial. That is much helpful for visually challenged users. Where on the contrary 87% and 32 % of the user found it lacking in the TapTapSee and VizWiz respectively.

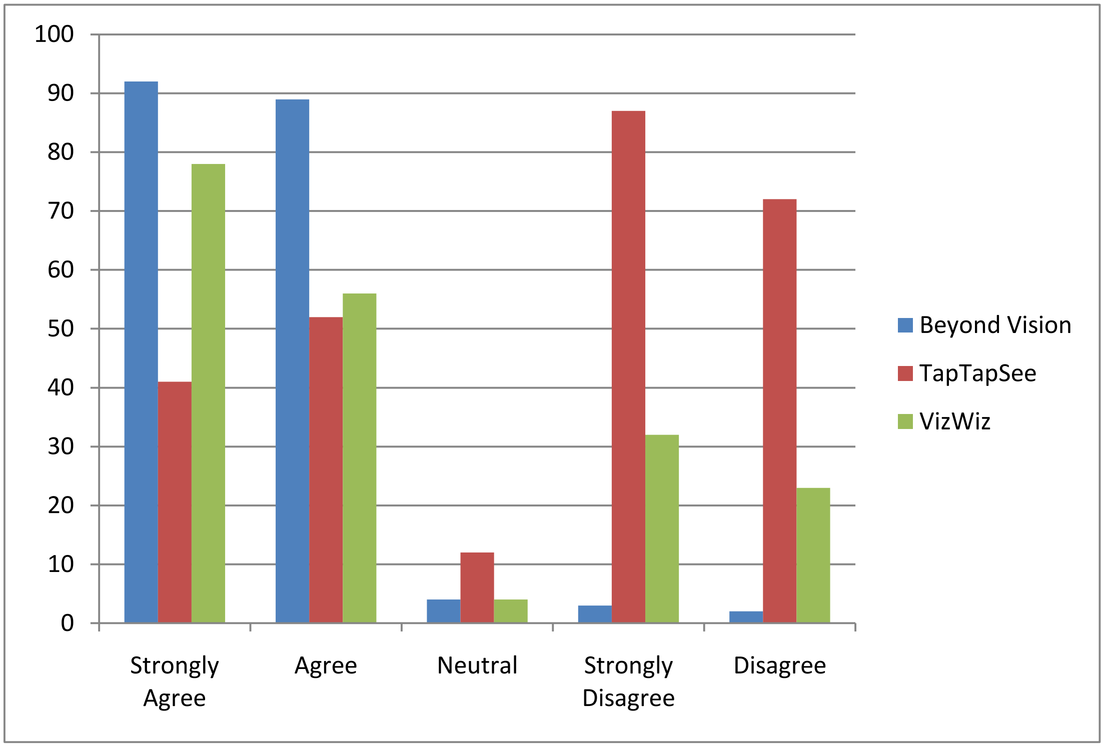


Figure 5.9: Adequate help and guidance

The figure-5.10 shows the user response when asked about whether the interface of this application was good or not. According to 87% of the users, the user interface of BEYOND VISION was found friendly and pleasant to interact with. Because of having all menu items are placed on proper location and audio controlled so that can be accessible for visually challenged people without losing anywhere. On the other hand, more than 53% and 46% users thought that the user interface of the TapTapSee and VizWiz is not friendly as much as BEYOND VISION is.

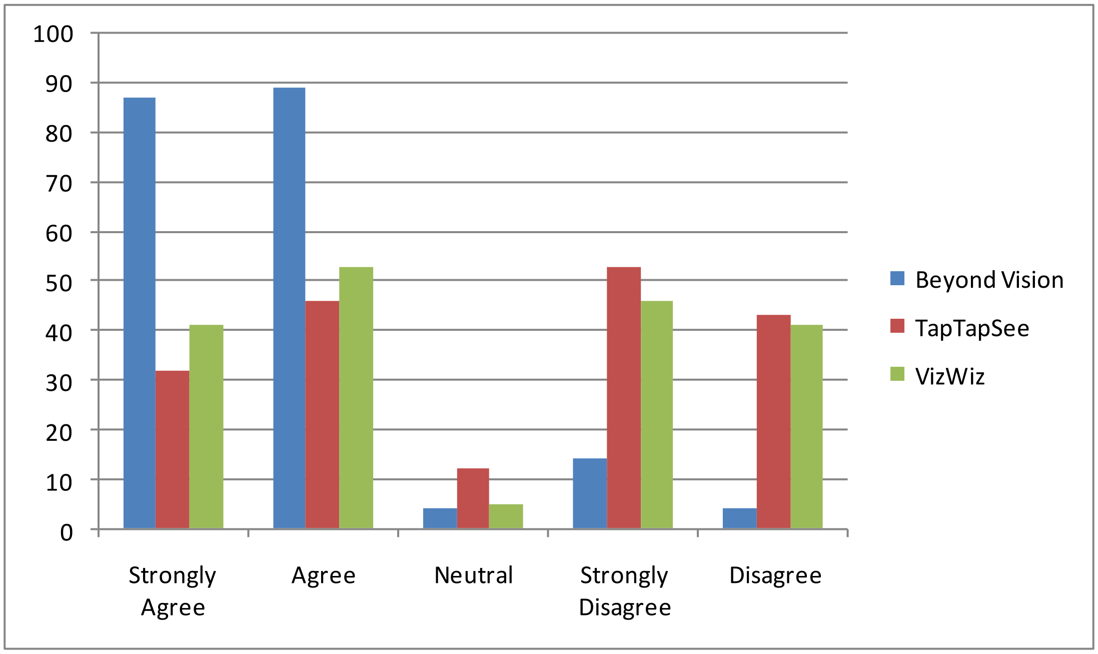


Figure 5.10: Appealing Interface

5.4. Overall Usability of "TapTapSee" VizWiz and "Beyond Vision"

We also asked the participants to rate the overall usability of both the applications; which application they found more usable and effective. Visually challenged participants evaluated the applications as shown in figure 5.11.

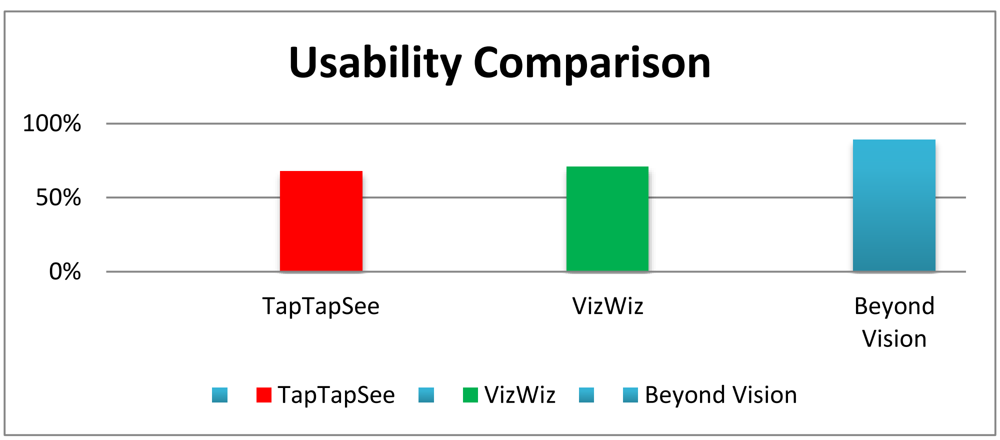


Figure 5.11: Usability Comparison of TapTapSee See, VizWiz and Beyond Vision

By mapping all of the survey results of apps we found Beyond Vision as more effective and usable application for visually challenged people as compared to TapTapSee and VizWiz.

CHAPTER 6

6 Conclusion and Future work

6.1. Conclusion

In this research work, a framework is presented. It is a mobile system that enables visually impaired people to identify items in their surroundings using remote human volunteer system. This project represents a novel change in how assistive technology works, directly inspired by how visually impaired people overcome many accessibility and usability shortcomings today – ask a sighted person. This application being very user-friendly and interactive would be very helpful for the users to do their simple routines, keep a record of their action items and tag those to the images where it has to be done.

Our approach can make this easier while keeping the users in control. By using Android SDK and Eclipse as the development environment the application is built keeping in mind about the design standards and maintainability of the code.

As we move forward, we plan to directly engage with visually challenged people to help test our approach. We will start with formal lab studies to prove its effectiveness and then release the application to many users to get results from the field. Engaging the visually impaired users in this way is of equal importance to the success of the project as getting the technology right. As just one example of why this is important, users may need to collectively help one another imagine uses for “Beyond Vision”.

“Beyond Vision” is tested on many Android devices to check the functionality and UI of the application. Samsung Note II, Samsung Galaxy and many other devices having, OS 4.1.2 or greater. These are the few of the devices which were used to run the application.

“Beyond Vision” is tested on many Android devices to check the functionality and UI of the application. Samsung Note II, Samsung Galaxy and many other devices having, OS 4.1.2 or greater. These are the few of the devices which were used to run the application.

6.2. Future Work

This work was a beginner application for object identification there is always more to add-on and enhances this application to provide a better end-user experience. It can be integrated with “Mechanical Turk” and “Mood Stocks” or created a new one of a similar kind to constantly recognize the images by matching via different techniques of computer vision.

In future, we will explore how to better integrate both human-powered and automatic services together. None of the participants wanted to use the application that take much more time and do not work out according to their requirements and especially because of their high prices and inconvenience.

REFERENCES

[1]. D. Lobo, “Web usability guidelines for smartphones a synergic approach,” in International Journal of Information and Electronics Engineering, 2011, vol. 1, no. 1, pp. 33-37.

[2] M. Black “Exploring mobile devices as grid resources: Using an x86 virtual machine to run boinc on an iPhone,” in 10th IEEE/ACM International Conference on Grid Computing, Washington, DC, USA, 2009,pp. 9-16.

[3] [July 2014] http://www.independentliving.org/docs5/mmiles3.html [ONLINE]

[4] [july 2014] http://www.who.int/mediacentre/factsheets/fs282/en/ [ONLINE]

[5] [June2014] Blindness rate in Pakistan [ONLINE] enewstribe.com/2013/04/26/around-two-million-people-are-completely-blind-in pakistan-says-expert/

[6] Yasuomi Une “Information presentation device realizing assistance of active understanding for visually-impaired people”. Active Media Technology, IEEE Conference , 2005,pp. 22-27

[7] Imai. “A New Touchscreen Application to Retrieve Speech Information Efficiently”in Consumer Electronics, IEEE Transactions , 2004, vol. 59 , Issue: 1 ,pp - 200 – 206.

[8] (October, 2013) “First Smart Phone” [Online] http://www.projectray. com/

[9] Nigel Bevan “Incorporating Human Factors into the Software Engineering Software Engineering Standards Symposium and Forum, 1997.Emerging International Standards. ISESS 97., Third IEEE International ,pp,169 - 179

[10] Misra, H. Users’ Computer Human Interface Capabilities in Information System ife Cycle" Engineering Management Conference, 2008.IEMC Europe 2008. ,pp. 1 – 5

[11] Noyes, J.M,"Working with users in system development: some methodological considerations"Integrating HCI in the Lifecycle, 7/1 - 7/3, 11 Apr 1995

[12] A. Freriksson and T. Parviainen, "Implementing user-centered devlopment in la University, 2006.

[13] A. Seffah, J. Gulliksen, and M. C. Desmarais, "An Introduction to Human-Centered Software Engineering: Integrating Usability in theDevelopment Process 2005.

[14] P. Zhang, J. Carey, D. Te'eni, and M. Tremaine, "Integrating Human-Computer velopment into the Systems Development Life Cycle: A Methodology", Communications of the Association for Information Systems, 2005, Vol.15, pp. 512-543.

[15] People: Integrating Human Factors into the Product Realization Process" IEEE cted areas in communications, 1991.

[16] J. P. D. Greenbaum, "A Personal Statement," Communications of theACM, June 1993, Vol.36, No. 4, pp. 47

[17] Julio Abascal, Human-Computer Interaction in Assistive Technology: From "Patchwork" to "Universal Design", IEEE SMC, Oct. 2002, vol 3, pp. 6-9

[18] [Online]http://www.youth2youth.ca/en/assistive-technology

[19] E. Ollson, 'What active users and designers contribute in the design process", Interacting with Computers, Avaialable online at: www.elsevierComputerScience.com. 2004, Vol. 16, pp. 377–400,

[20] G. Symon, "The work of IT system developers in context: an organizational case study", Human–Computer Interaction, 1998, vol. 13, No. 1, pp. 37–71

[21] Cesarano ,"Improving Usability of Web Pages for Blinds" Web Site Evolution, WSE 2007. 9th IEEE International Workshop ,2007, pp. 97 – 104

[22] Peters, J.-P. ,"Embedded reading device for blind people: a user-centered design" Information Theory. ISIT.Proceedings. International Symposium ,2004, pp.- 217 - 222

[23] Gupta,“Educational Computing for the Blind in India: Design, Development and Learning Impact” ,Technology for Education (T4E), IEEE Fourth International Conference,2012, pp. 168 - 171

[24] C., Stephanidis, A., Savidis, “Universal Access in theInformation Society: Methods, Tools, and Interaction Technologies”, Universal Access in the Information Society, Springer Berlin / Heidelberg,june 2011, vol 1,pp.37-48.

[25] [October 2013]World Health Organization, WHO , “Magnitude and causes of visual impairment” Fact Sheet N°282, 2004, http://www.who.int/mediacentre /factsheets/fs282/en/print.html[Online]

[26] Viisola, M., “Statistics on Children with Visual Impairments” ERIC Education Resource Information Center

[27] Hitchcock, C and Stahl, S. ,“Assistive Technology, Universal Design, Universal Design for Learning: Improved Learning Opportunities” Journal of Special Education Technology, 2003, vol 18,pp.29-37.

[28] L. Valdes, "Accessibility on the Internet", available http://www.un.org/esa/socdev/ enable/disacc00.htm

[29] D. Bolchini, S. Colazzo, P. Paolini, D.Vitali, "Designing Aural Information Architectures", SIGDOC'06, ACM Press, 2006

[30] D. Bolchini, S. Colazzo, P. Paolini, "Requirements for Aural Web Sites", 8th IEEE International Symposium on Web Site Evolution, IEEE CS Press, 2006, Pp.:75 – 82

[31] Cesarano ,“Improving Usability of Web Pages for Blinds” Web Site Evolution,. WSE. 9th IEEE International Workshop ,2007, pp. 97 - 104

[32] H. Takagi, C. Asakawa, K. Fukuda, J. Maeda, "Site-wide Annotation: Reconstructing Existing Pages to be Accessible", International ACM SIGACCESS Conference on Computers and Accessibility, Assets 2002, ACM Press, July 8-10, 2002

[33] (2013, October 9)World Health Organization.. World Health Organization. Retrieved October 2009, from Regional Office for the Eastern Mediterranean:[Online] http://www.emro.who.int/pressreleases/2008/no18.htm

[34] O'Brien, S. (n.d.). About. Retrieved October 2009, from Senior Living: http://seniorliving.about.com/od/visionproblems/a/vision_loss_stu.htm

[35] American Printing House for the Blind, Inc. (2007, September 30). American Printing House for the Blind. Retrieved September 2009, from About: http://www.aph.org/about/ar2007.html

[36]"Basic Human Computer Interface for the Blind" Eighth LACCEI Latin American and Caribbean Conference for Engineering and Technology (LACCEI'2010) "Innovation and Development for the Americas", June 1-4, 2010

[37] K. Potosnak. , "Human Factor:Mental Model: Helping Users Understand Software",September 1989

[38] Human Computer Interaction, Retrieved on November 29, 2009,from: http://alumni.media.mit.edu/~spiegel/papers/HCI.pdf.

[39] T. Chambel., P. Antunes., C. Duarte, L. Carrico, N. Guimaraes "Teaching Human-Computer Interaction to Blind Students", HCI Educators 2007, Aveiro, Portugal

[40] J. Preece, Yvonne Rogers, H. S. D.Benyon, S.Holland, Tom Carey,"Human Computer Interaction", Addison- Wesley

[41] Norman, D., "The Design of Everyday Things", New York:Basic Books

[42] Mental Model and Usability, Retrieved on November 29, 2009, from: http://www.lauradove.info/reports/mental%20models.htm.

[43] N. Aziz, N. H. M, Roseli, and A.A. Mutalib, "Assistive Courseware for Visually-Impaired", IVIC 2009, LNCS 5857, pp. 905-915, 2009

[44] K. Shinohara,"Designing Assistive Technology for Blind Users", ASSETS'06, , Portland, Oregon, USA, October 22-25, 2006

[45] P. E. Lanigan, A.M., Paulos, A.W, Williams, D. Rossi and P. Narashimhan, "Trinetra: Assistive Technology for Grocery Shopping for the Blind", ISWC2003,:vol 8,pp. 147-148

[46] K S. H. Kurniwan, A.G. Sutcliffe, and P.L. Blenkhorn, " How Blind

Users's Mental Models Affect Their Perceived Usability of an Unfamiliar Screen Reader", INTERACT'03,2007,Vol 5,pp.79-85.

[47] "Mental Model of Blind Users to Assist Designers in System Development" Information Technology (ITSim), 2010 International Symposium in ,2010 ,vol:1,pp.15-17

[48] M.-A. Espinosa, S. Ungar, E. Ochaíta, M. Blades, C. Spencer.Comparing methods for introducing blind and visually impaired people to unfamiliar urban environments. Journal of Environmental Psychology,1998, pp.277-287

[49] Majid, R.A. A Survey on User Involvement in Software Development Life Cycle from Practitioner's Perspectives. Computer Sciences and Convergence Information Technology (ICCIT), , 5th International Conference 2010,vol 4,pp207-217.

[50] (October, 2013) Eye data [Online] http://www.nei.nih.gov/eyedata/ blind.asp

[50] [May 2014] Usability Issues of smartphone apps [online] http://internationalscienceindex.org/search?q=Eyes-free%20shell

[51] Anam Ashraf, Arif Raza, "Challenges in Requirement Elicitation of Cellular Applications: For Visually Challenged People" 4th International Research Conference on Computer Science, Engineering, Management Sciences and Social Sciences, 2014.

[52] [June 2014] Usability heuristics [Online] http://www.nngroup.com/articles/ten-usability-heuristics/

[53] [July 2014] Usability issues of smartphone application [Online] http://internationalscienceindex.org/search?q=Eyes-free%20shell

[54] [May 2014] Norman's Usability [Online] http://architectingusability.com /2012/06/28/ donald-normans-design-principles-for-usability/

[55] [July 2014] Golden rules of Usability Design [Online] https://www.cs.umd.edu/users/ben/goldenrules.html

[56] R. Ting, "The advanced mobile learning practices: learning features and

implications," 7th IEEE International Conference on Advanced Learning Technologies, (ICALT), Taipei, Taiwan, 2007,vol2,pp. 718 -720

[57]TaptapSee"[online]http://www.taptapseeapp.com/ [accessed in july 2014]

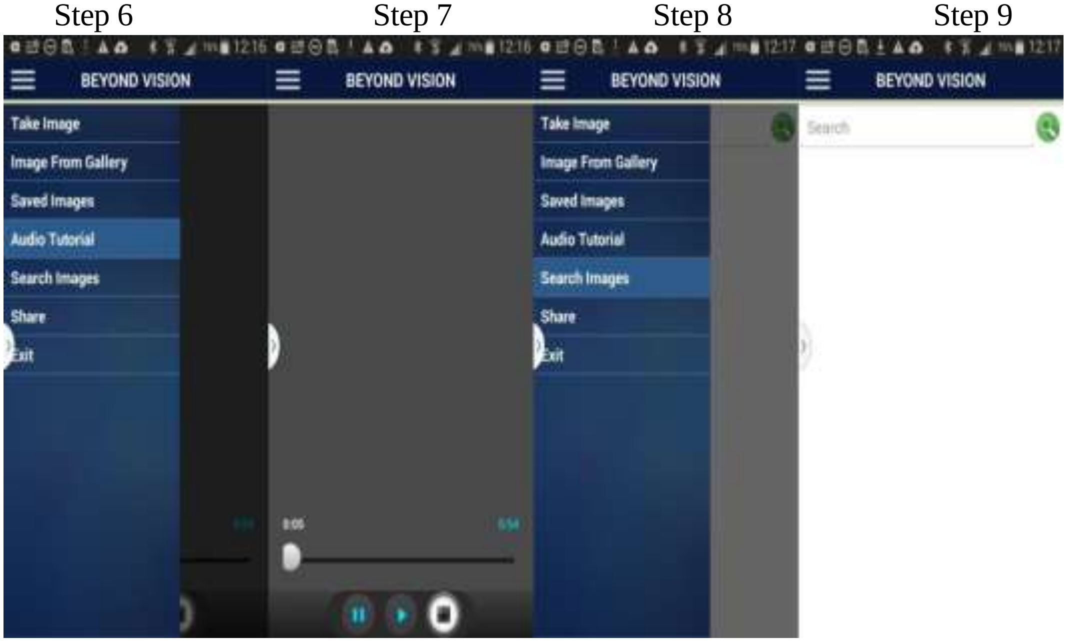
[58] Viz Wiz [Online] nhttps://itunes.apple.com/PK/app/ id439686043?mt =8(accessed on September 2013)

Appendix A: Stepwise Snapshots of "Beyond Vision" Application

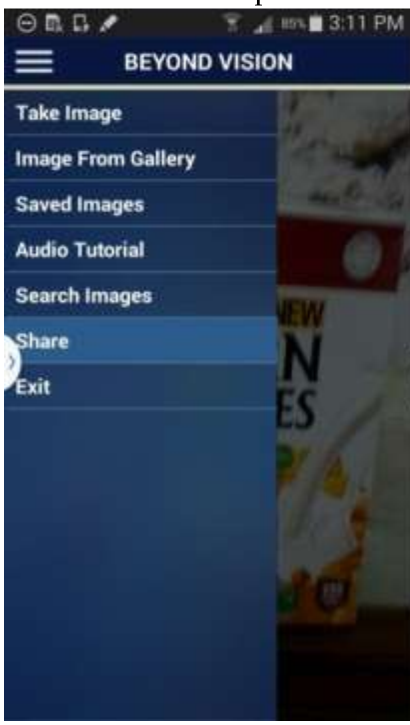
Step 1 Step 2 Step 3 Step 4 Step

5

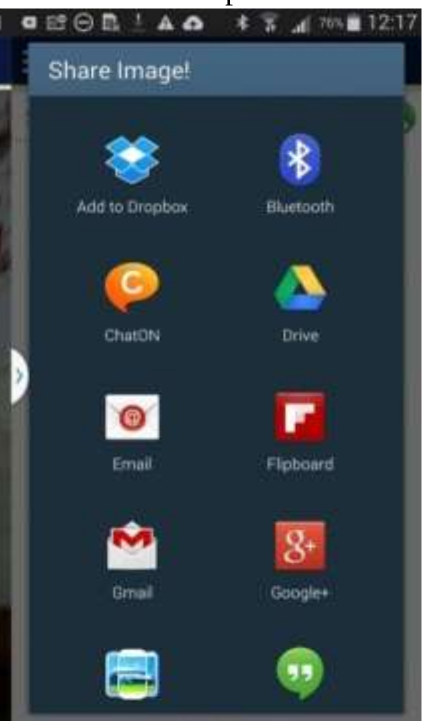
Step 6 Step 7 Step 8 Step 9



Step 10



Step 11



Stepwise Snapshots of Beyond Vision Application

Appendix B:

Image Detection

Camera Fragment Class

```
public class CameraFrament extends Fragment {
private static final String TAG = "CamTestActivity";
private Preview preview;
private Button buttonClick;
private Camera camera;
private HomeActivity mHomeActivity;
private FrameLayout mFrameLayout;
private boolean flagImageServe = false;
public CameraFrament() {
}
public View onCreateView(LayoutInflater inflater, ViewGroup container,
Bundle savedInstanceState) {
finalViewrootView = inflater.inflate(R.layout.activity_cameraframent, container,
false);
mHomeActivity=(HomeActivity) HomeActivity.getActivity();
preview = new Preview(mHomeActivity,
(SurfaceView) rootView.findViewById(R.id.surfaceView));
preview.setLayoutParams(new LayoutParams(LayoutParams.MATCH_PARENT,
LayoutParams.MATCH_PARENT));
mFrameLayout = (FrameLayout) rootView.findViewById(R.id.layout);
mFrameLayout.addView(preview);
preview.setRotation(180);
```

```
preview.setKeepScreenOn(true);
flagImageServe = false;
preview.setOnClickListener(new OnClickListener() {
@Override
public void onClick(View arg0) {
if (!flagImageServe) {
if (!SharedPreferencesHelper.isOnline(getActivity())) {
AlertMessage.showMessage
(getActivity(),
"Internet Connection",
"Please Check Internet Connection");
return;}
busyNow = new BusyDialog(getActivity(), true);
busyNow.show();
camera.takePicture(shutterCallback, rawCallback,
jpegCallback);}}});
return rootView;
}@Override
public void onResume() {
super.onResume();
// preview.camera = Camera.open();
mHomeActivity = (HomeActivity) HomeActivity.getActivity();
camera = Camera.open();
camera.setDisplayOrientation(90);
camera.startPreview();
preview.setCamera(camera);}
@Override
public void onPause() {
```

```
if (camera != null) {

camera.stopPreview();
preview.setCamera(null);
camera.release();
camera = null;}
super.onPause();}
private void resetCam() {
camera.startPreview();
preview.setCamera(camera);
}
private void refreshGallery(File file) {
// Intent mediaScanIntent = new Intent(
// Intent.ACTION_MEDIA_SCANNER_SCAN_FILE);
// mediaScanIntent.setData(Uri.fromFile(file));
// sendBroadcast(mediaScanIntent);
}
ShutterCallback shutterCallback = new ShutterCallback() {
public void onShutter() {
// Log.d(TAG, "onShutter'd");
AudioManager mgr = (AudioManager)
mHomeActivity.getSystemService(Context.AUDIO_SERVICE);
mgr.playSoundEffect(AudioManager.FLAG_PLAY_SOUND);
}
};
PictureCallback rawCallback = new PictureCallback() {
public void onPictureTaken(byte[] data, Camera camera) {
// Log.d(TAG, "onPictureTaken - raw");
}
```

```
};
PictureCallback jpegCallback = new PictureCallback() {
public void onPictureTaken(byte[] data, Camera camera) {
new SaveImageTask().execute(data);
resetCam();
Log.d(TAG, "onPictureTaken - jpeg");
}
};
private class SaveImageTask extends AsyncTask<byte[], String, String> {
@Override
protected String doInBackground(byte[]... data) {
FileOutputStream outStream = null
// Write to SD Card
try {
File sdCard = Environment.getExternalStorageDirectory();
File dir = new File(sdCard.getAbsolutePath() + "/camtest");
dir.mkdirs();

String fileName = String.format("%d.jpg",
System.currentTimeMillis());
File outFile = new File(dir, fileName);

outStream = new FileOutputStream(outFile);
outStream.write(data[0]);
outStream.flush();
outStream.close();
Log.d(TAG, "onPictureTaken - wrote bytes: " + data.length + " to " +
outFile.getAbsolutePath());
AppConstant.imageUrl = outFile.getAbsolutePath().toString();
```

```
Intent intent = new Intent(getActivity(), GalleryActivity.class);
intent.putExtra("selectedImagePath", outFile.getAbsolutePath()
.toString());
startActivity(intent);
// refreshGallery(outFile);
// resultsMessage =
// multipartDataInfo(outFile.getAbsolutePath());
        Log.w("results", "are" + resultsMessage);
        } catch (FileNotFoundException e) {
        e.printStackTrace();
        } catch (IOException e) {
        e.printStackTrace();
        } finally {
        }
        return null;
        }
        protected void onPostExecute(String result) {
        // TODO Auto-generated method stub
        super.onPostExecute((String) result);
        if (busyNow != null) {
        busyNow.dismis();
        }
        // Toast.makeText(getActivity(), "" + resultsMessage, 3000).show();
        flagImageServe = false;                                          }
        }

        BusyDialog busyNow;
        String repose_results = "", resultsMessage = "";;
        public String multipartDataInfo(String fileUrl)
```

```
throws UnsupportedEncodingException {
final MultipartEntity reqEntity = new MultipartEntity();
reqEntity.addPart("method", new StringBody("fileupload"));
reqEntity
.addPart(
"userid",
new StringBody(SharedPreferencesHelper
.getUserID(getActivity())));
File mFile = new File(fileUrl);
// FileBody fileBody = new FileBody(mFile);
FileBody fileBody = new FileBody(mFile,"image/jpg");
reqEntity.addPart("file", fileBody);
repose_results = HTTPHandler.postDataWithMultipartImage(
"http://www.anamkhangroupbd.org/blindapp/account.php",reqEntity);
return repose_results;
}
}
```

Utilities on Server Side

Server Utility Class

```
public final class ServerUtilities {
private static final int MAX_ATTEMPTS = 5;
private static final int BACKOFF_MILLI_SECONDS = 2000;
private static final Random random = new Random();
/**
* Register this account/device pair within the server.
*
*/
/* static void register(final Context context, String name, String email, final
String regId) {
```

```
Log.i(TAG, "registering device (regId = " + regId + ")");
String serverUrl = SERVER_URL;
Map<String, String> params = new HashMap<String, String>();
params.put("regId", regId);
params.put("name", name);
params.put("email", email);
long backoff = BACKOFF_MILLI_SECONDS + random.nextInt(1000);
// Once GCM returns a registration id, we need to register on our server
// As the server might be down, we will retry it a couple
// times.
for (int i = 1; i <= MAX_ATTEMPTS; i++) {
Log.d(TAG, "Attempt #" + i + " to register");
try {
displayMessage(context, context.getString(
R.string.server_registering, i, MAX_ATTEMPTS));
post(serverUrl, params);
GCMRegistrar.setRegisteredOnServer(context, true);
String message = context.getString(R.string.server_registered);
CommonUtilities.displayMessage(context, message);
return;
} catch (IOException e) {

// Here we are simplifying and retrying on any error; in a real
// application, it should retry only on unrecoverable errors
// (like HTTP error code 503).
Log.e(TAG, "Failed to register on attempt " + i + ":" + e);
if (i == MAX_ATTEMPTS) {
break;
} try {
```

```
Log.d(TAG, "Sleeping for " + backoff + " ms before retry");
Thread.sleep(backoff);
} catch (InterruptedException e1) {
// Activity finished before we complete - exit.
Log.d(TAG, "Thread interrupted: abort remaining retries!");
Thread.currentThread().interrupt();
return;
}
// increase backoff exponentially
backoff *= 2;
}
}
Stringmessage=context.getString(R.string.server_register_error,
MAX_ATTEMPTS);
CommonUtilities.displayMessage(context, message);
}
*//**
* Unregister this account/device pair within the server.
*//*
static void unregister(final Context context, final String regId) {
Log.i(TAG, "unregistering device (regId = " + regId + ")");
String serverUrl = SERVER_URL + "/unregister";
Map<String, String> params = new HashMap<String, String>();
params.put("regId", regId);
try {
post(serverUrl, params);
GCMRegistrar.setRegisteredOnServer(context, false);
String message = context.getString(R.string.server_unregistered);
CommonUtilities.displayMessage(context, message);
```

```
} catch (IOException e) {
// At this point the device is unregistered from GCM, but still
// registered in the server.
// We could try to unregister again, but it is not necessary:
// if the server tries to send a message to the device, it will get    // a
"NotRegistered" error message and should unregister the device.
String message = context.getString(R.string.server_unregister_error,
e.getMessage());
CommonUtilities.displayMessage(context, message);
}

*//**
* Issue a POST request to the server.
*
* @param endpoint POST address.
* @param params request parameters.
*
* @throws IOException propagated from POST.
*//*
private static void post(String endpoint, Map<String, String> params)
throws IOException {
URL url;
try {
url = new URL(endpoint);
} catch (MalformedURLException e) {
throw new IllegalArgumentException("invalid url: " + endpoint);
}
StringBuilder bodyBuilder = new StringBuilder();
Iterator<Entry<String, String>> iterator = params.entrySet().iterator();
```

```
// constructs the POST body using the parameters
while (iterator.hasNext())
{
Entry<String, String> param = iterator.next();
bodyBuilder.append(param.getKey()).append('=')
.append(param.getValue());
if (iterator.hasNext()) {
bodyBuilder.append('&');
}
}
String body = bodyBuilder.toString();
Log.v(TAG, "Posting '" + body + "' to " + url);
byte[] bytes = body.getBytes();
HttpURLConnection conn = null;
try {
Log.e("URL", "> " + url);
conn = (HttpURLConnection) url.openConnection();
conn.setDoOutput(true);
conn.setUseCaches(false);
conn.setFixedLengthStreamingMode(bytes.length);
conn.setRequestMethod("POST");
conn.setRequestProperty("Content-Type",
"application/x-www-form-urlencoded;charset=UTF-8");
// post the request
OutputStream out = conn.getOutputStream();
out.write(bytes);
out.close();
// handle the response
int status = conn.getResponseCode();
```

```
if (status != 200) {
throw new IOException("Post failed with error code " + status);
}
} finally {

if (conn != null) {
conn.disconnect();
}   } }*}
```

Common Utility Class

```
public final class CommonUtilities {
// give your server registration url here
// static final String SERVER_URL =
"http://10.0.2.2/gcm_server_php/register.php";
// Google project id
public  static final String SENDER_ID = "946246647043";
//972241768901//797770868098
//AIzaSyBNTszut9VRbVfzNFD79JbnQPKpF2rATpo
/**
* Tag used on log messages.
*/
public  static final String TAG = "Invitation GCM";
public  static final String DISPLAY_MESSAGE_ACTION =
"com.blindpeople.pusnotification.DISPLAY_MESSAGE";
public  static final String EXTRA_MESSAGE = "message";
/**
* Notifies UI to display a message.
* <p>
* This method is defined in the common helper because it's used both by
* the UI and the background service.
```

```
*
* @param context application's context.
* @param message message to be displayed.
*/
public static void displayMessage(Context context, String message) {
Intent intent = new Intent(DISPLAY_MESSAGE_ACTION);
intent.putExtra(EXTRA_MESSAGE, message);
context.sendBroadcast(intent);
}
}
```

Text to Speech

```
private void sayHello(String spaceText) {
// Select a random hello.
mTts.speak(spaceText, TextToSpeech.QUEUE_FLUSH, null);
}
public void onInit(int status) {
if (status == TextToSpeech.SUCCESS) {
int result = mTts.setLanguage(Locale.US);
if (result == TextToSpeech.LANG_MISSING_DATA
|| result == TextToSpeech.LANG_NOT_SUPPORTED) {
Log.e("Language", "Language is not available.");
} else {
}
} else {
Log.e("Language", "Could not initialize TextToSpeech.");
}}
```

Notification Class

```
public class NotificationMobel {
private String condition;
```

```
private String senderid;
private String image_url;
private String imageid;
private String userid;
private String responsemessage;
private String voice_url;
public String getCondition() {
return condition;
}
public void setCondition(String condition) {
this.condition = condition;
}
public String getSenderid() {
return senderid;
}
public void setSenderid(String senderid) {
this.senderid = senderid;
}
public String getImage_url() {
return image_url;
}
public void setImage_url(String image_url) {
this.image_url = image_url;
}

public String getImageid() {
return imageid;
}
public void setImageid(String imageid) {
```

```
this.imageid = imageid;
}
public String getUserid() {
return userid;
}

public void setUserid(String userid) {
this.userid = userid;
}
public String getResponsemessage() {
return responsemessage;
}
public void setResponsemessage(String responsemessage) {
this.responsemessage = responsemessage;
}
public String getVoice_url() {
return voice_url;
}
public void setVoice_url(String voice_url) {
this.voice_url = voice_url;
}
@Override
public String toString()
{
return "NotificationMobel [condition=" + condition + ", senderid="

+ senderid + ", image_url=" + image_url + ", imageid="
+ imageid + ", userid=" + userid + ", responsemessage="
+ responsemessage + ", voice_url=" + voice_url + "]";}}
```