THIRD EYE – A MOBILE APPLICATION FOR VISUALLY IMPAIRED PEOPLE TO ASSIST WITH DAILY TASKS

22_23-J 83

Project Proposal Report

A.D. Amarasinghe – IT19133614

B.Sc. (Hons) Degree in Information Technology specializing in Information Technology

Department of Computer Science and Software Engineering

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DECLARATION

We declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
A.D. Amarasinghe	IT19133614	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Uthpala Samarakoon (Signed) — 14th October 2022

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Signature of the supervisor: Date:

ABSTRACT

The eye is one of the major organs of a living being out of five sensory organs. Losing sight causes a person to become partially deactivated in his or her daily activities by sitting in a corner of the room for the whole day without knowing the shapes or colors of the world. Because of a few medical factors, visually impairment can happen. While some situations can be cured and treated, some incidents can't be recovered. Due to the busyness of today's people, allocating a separate time for a visually impaired person is much more difficult while balancing their time as well. Thanks to the varied development of today's technology, there are so many smart systems and products for visually impaired people to do their own tasks by themselves, beyond the traditional techniques like white canes, guide dogs, trained human assistants, smart glasses, and so on. But the disadvantage of modern techniques is that the products are considerably more expensive than a normal person can afford. So, despite the fact that solutions exist, visually impaired people must continue to live without changing their daily routines.

This project focuses on a mobile application that a blind or color-blind person can easily handle via simple actions like finger taps, voice commands, or swiping the screen to accomplish small orders, and also with the help of voice assistants and read-aloud techniques. The primary goal of developing this "Third Eye" mobile application is to assist visually impaired people with navigation, object recognition, text reading, and color blindness. Because this project mainly depends on the mobile phone camera, the user doesn't need to worry about wearing external equipment or the lateness of receiving particular details. Even though there are hundreds of existing systems, using modern technology to add new features and meet multiple needs from a single free application increases the uniqueness of this concept rather than them.

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LIST OF ABBREVIATIONS

Abbreviation	Description
API	Application Programming Interface
BVI	Blind-Visually Impaired
CCTV	Closed-Circuit Television
CRUD	Create Read Update Delete
CV	Computer Vision
DB	Database
GPS	Global Positioning System
GPU	Graphical Processing Unit
MP	Mega Pixel
OS	Operating System
RFID	Radio Frequency Identification
SQL	Structured Query Language
TPU	Tensor Processing Unit
UI	User Interface
UX	User Experience
WHO	World Health Organization

1. INTRODUCTION

1.1 Background & Literature Survey

When considering living beings, the eye or vision is one of the major components out of five sensory organs [1]. Losing sight causes a person to become partially deactivated in his or her daily activities by sitting in a corner of the room for the whole day without knowing the shapes or colors of the world. According to WHO statistics, 2.2 billion people worldwide have a near or distance vision impairment [2]. Out of them, there are at least 43 million people around the world suffering from blindness, and another 300 million people are estimated to have color vision deficiencies [3][4]. When considering the major causes of blindness, genetic factors, external accidents to the retina, some noncommunicable diseases like diabetes, glaucoma, or sometimes excessive use of digital devices can be the main cause [5][6]. Depending on the severity of the situation, some cases can be cured while there's no specific treatment for some scenarios [1][7]. Due to that, regardless of age or gender, being visually impaired, wastes a significant amount of people's working power. As discovered, even though visually impaired people lost their sight, their other sensory organs, especially the hearing ability, are considerably greater than the normal healthy person because they have trained the ability to hear to adapt to their environment by recognizing voices and noises and also preparing for the warnings very well [8]. This ability is sometimes very good for some occupations, like fire fighters, to identify security alarms, and also for police and paramedics, especially in the music industry. So, if a visually impaired person gets good training and practice for these skills, he or she can also use their valuable time to do useful things, at least using their hearing ability [9].

Thanking to the development of today's technology, there are so many smart systems and applications that have developed as assistant tools for visually impaired people to do their day-to-day tasks without the help of the traditional techniques like white canes, trained dogs, human or AI assistants [10][11]. Not only the mobile applications, there are so much equipment also invented to support BVI people [12]. When considering about the main requirements of blind people, so many applications have invented focusing on navigation, obstacles identifying, voice assistants, and read-aloud techniques [10][13]. Due to the complexity of understanding of how to use the system and being high cost of most products, still most visually impaired people especially in third world countries are using traditional techniques [14]. Another major problem of stuck in old techniques is the delay of giving the certain output, no way to make sure the accuracy of the information or sometimes the

difficulties of using the application or the product [14]. The Figure 1 below shows the survey which was conducted among the blind and visually impaired in Saudi Arabia using digital forms. A total of 164 people responded to the survey most of them using the VoiceOver function [15].

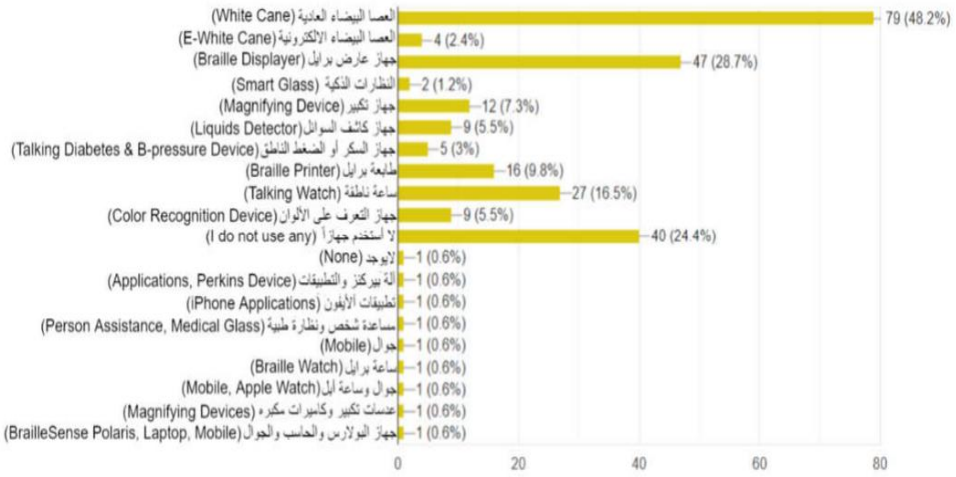

Figure 1.1: The use of different assistive technology by the survey participants in Saudi Arabia

According to the above bar graph, even though there are so many techniques existing, most of the people (48.2%) still use the white cane, the second majority (28.7%) depend on the Braille displayer, which is the alphabet technique specially invented for the blind, and the third majority (24.4%) do not use any of the technologies. The number of users who use modern technologies like smart glasses, watches, and devices is comparatively lower. As already mentioned above, the main reasons for still relying on traditional techniques are the complexity of modern technologies and also that the prices of these smart systems are considerably high that a normal person cannot afford. Smart glasses for colorblind people typically start at around $3500 [16]. To reduce these issues, simple mobile applications that can be used by blind people were introduced.

Even in the mobile applications, most visually impaired people's main requirements were that they needed to navigate to locations without the human assistants and also that they should be able to avoid the obstacles using that particular mobile application as well. According to the research, for this navigation purpose, most blind users use any kind of navigating application with the additional help of white canes [10].

The below bar graph indicates how the number of users from the above survey use the different kinds of mobile applications for the aiming of navigation and obstacle identification. As the most common mobile application, the highest number of participants

(95.5%) are using Google Maps. "Be my eyes" and "Ariadne GPS" take the second and third places, respectively, by obtaining 30.3% and 7.9% percentages of the whole count.

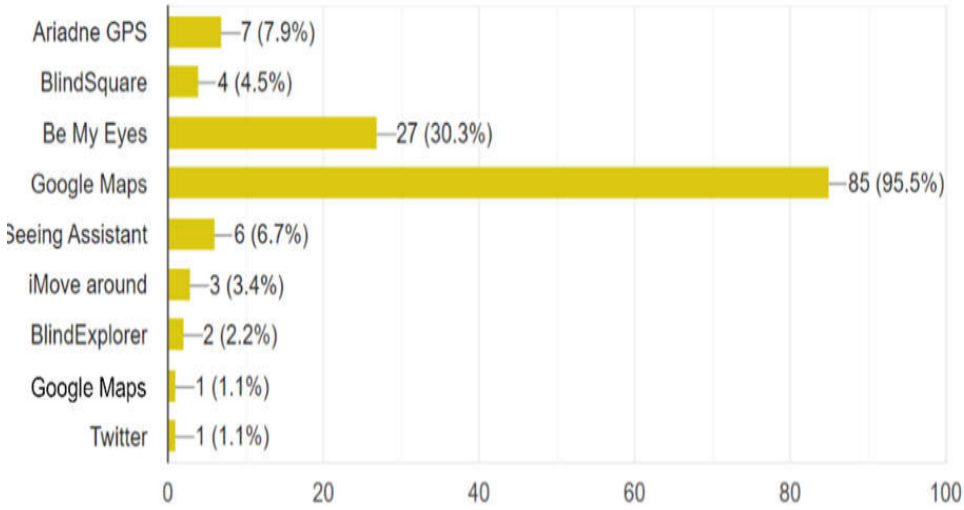

Figure 1.2: The distribution of participants using different navigation applications

When considering the satisfactory level of these mobile applications, these kinds of results were taken from 164 respondents, as the pie chart shows below.

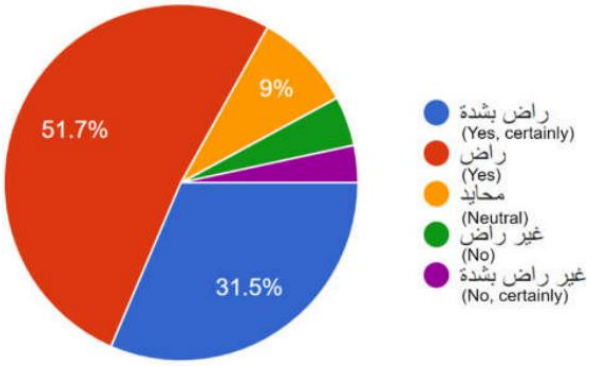

Figure 1.3: Satisfaction level of navigation applications

Despite the fact that the majority of participants said the mobile applications were adequate, more than 15% were dissatisfied with the functionalities. So, a mobile application that covers all these drawbacks is highly needed because the users are complaining of various problems that they experienced while using the existing applications.

Most of the time, GPS is the background supporter of these applications like Google Apps, Be my eyes, BlindSquare, Ariadne GPS so on [17][18]. Via a voice assistant or a vibration technique, the system guides the user to where to navigate or where to go [11]. But for

restricted areas where construction or forbidden places are underway, these apps don't inform the users to not go. Another thing is that even though there are so many smart systems for outdoor navigation, there's no specific system to guide the user to navigate in large indoor areas such as airports, supermarkets, hospitals, and so on [13]. Even though some systems have been implemented for indoor navigation, they guide the user to a limited level only. It's mainly because most mobile applications depend on the network, and these navigation apps mostly rely on live data. Due to these network signals are blocked or weakened in large indoor areas, they are not strong enough to support the application [13]19

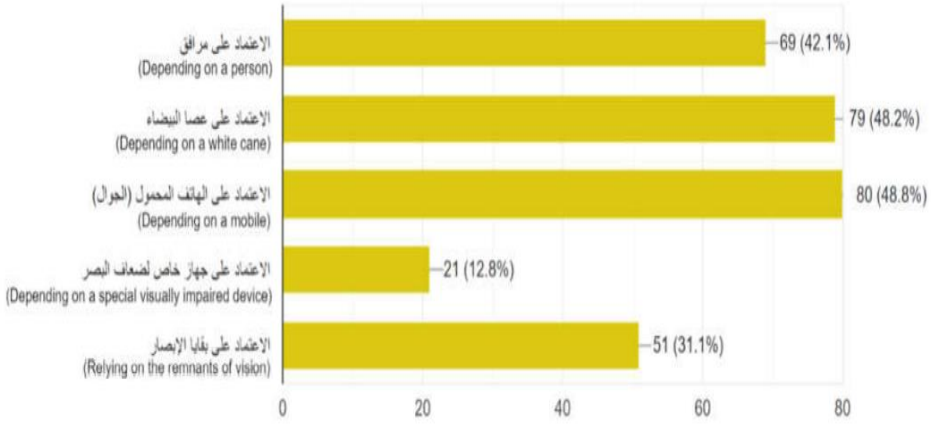

Figure 1.4: Survey participant's dependency in indoor environments

At 49% and 48%, respectively, the primary tools used by the visually impaired were white canes and mobiles, followed by an accompanying person at 42%. Whatever the other indoor areas, most users are comfortable enough to use a mobile phone or mobile application for indoor navigation, especially inside their homes. It is mainly because the home is the most familiar and safest environment for indoor navigation [19].

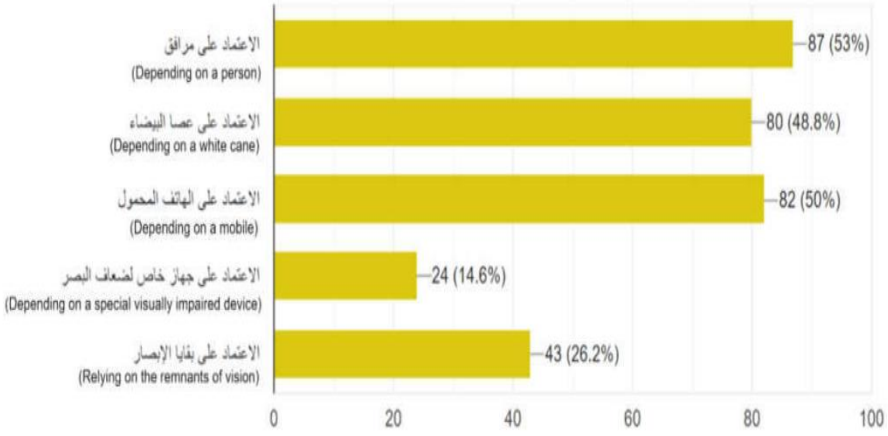

Figure 1.5: Survey participant's dependency in outdoor environments

When considering the outdoor navigation survey results, 53% of participants still rely on a person. Least number of participants (14.6%) are depending on visually impaired devices. That clearly indicates that they are not very confident about the accuracy of the mobile applications or smart devices.

Due to the mismatches and the delays of the data processing, the blind users face trouble because they are not able to identify where they are standing now. According to the responses of the surveys done for blind people, it is such an awkward feeling to be lost in unfamiliar places. They said that sometimes they felt the fear of death to their lives because of to be with strangers. So, they feel much comfortable to be inside home even they are willing to see the outer world so much [7][20].

In this report, the main focus is going to the development of a mobile application to be used easily by visually impaired people, which covers all the drawbacks of existing smart systems and mobile applications. In a world where technology is advancing at a rapid pace, it is critical to do something effective for differently abled people to encourage them to join the human race and use their skills and efforts for the greater good. This is where equability in society stands for.

1.2 Research Gap

Even though many visually impaired people still depend on traditional techniques, let's have a look at them. The below graph indicates common techniques with a small description of each equipment, which was collected from the previous research.

Technique	Description
White cane 	The most common and simple equipment for blind navigation and obstacle identification. This is also used as an identification symbol for blind people [10]. A cane that is approximately 4 inches shorter than the user's height and some canes are fordable, which makes them much more portable [21]. This is usually available around $20 - $80 (Rs. 8000 - Rs32000).
Guide dog 	Because they are living beings, blind people feel much more comfortable and safer when they use guide dogs for navigation purposes [10]. Guide dogs are trained to assist with day-to-day tasks for blind people. Usually, they can guide the user to a particular destination. They are also trained to carry goods, remind people of medications, and act as security guards [22].
Human assistant 	Most developed countries pay human assistant to look after the blind. There are societies and communities for human assistance for blind people [10][23]. This is one of the easiest ways for blind people to navigate because, there is no need for training, maintenance, or repairs. A blind person is guided by the assistance by holding on to their arm.
Tactile paving 	They are such similar to braille alphabet technique. Similar to Braille. The paving was designed to notify a visually impaired pedestrian of any changes in the area. There are three types of tactile paving patterns: Attention, Guiding, and Lozenge [24].

Tactile map 	Tactile maps are maps designed to be read by touch which primarily designed for blind and partially sighted users [25]. Unlike standard maps, these maps need to be printed. The user can either print the map yourself at no charge using an embosser, a swell paper printer or a 3D printer, or can order an affordable 3D print about $40 (Rs. 15000)
Smart cane 	Enhances white cane's capability by detecting objects from knee to head height in front of a person. the device is available around $500 - $6000 (Rs. 200000 – Rs. 2200000). It used to charge the battery with one full charge lasting up to five hours of usage time. Some smart canes have a camera and also its own voice assistant to guide the user navigation [26].
Smart glass 	A smart glass specially made for obstacle identification and text reading purposes using the camera itself. The glasses are also equipped with a compass, a GPS, and a gyroscope, a tool that measures the orientation of the glasses [16][27]. Via a voice assistant, a set of headphones provides directions or reads signs aloud. Users can buy this product for $3,500 (Rs.1300000).
Navigation belt 	This a wearable device that uses vibrations to help guide the wearer. The belt itself is equipped with 16 actuators that produce specific vibrations according to GPS information. Users simply key in their desired destination on their smartphone and the belt will do the navigating. The smart belt also gives users a sense of where true north is to give them a better understanding of how they are navigating a physical space [28][29].

Table 1.1: Traditional techniques and equipment for blind navigation

Likewise, some majorly visible disadvantages of each technique can be categorized according to some non-functional requirements as in the table shown below [10].

Technique	Usability	Security	Affordability of the cost	Accuracy	Efficiency	Maintenance	User friendliness
White cane	Medium	Low	High	Low	Low	Low	Low
Guide dog	Medium	High	Medium	Medium	Medium	High	Medium
Human assistant	High	High	Medium	High	High	Low	High
Tactile paving	Medium	Low	High	Medium	Low	Low	Low
Tactile map	Medium	Low	High	Medium	Low	Low	Low
Smart cane	Medium	Medium	Low	Medium	High	High	Medium
Smart glass	Medium	Medium	Low	Medium	High	High	Medium
Navigation belt	Medium	Medium	Low	Medium	Medium	High	Low

Table 1.2: Non-functional requirements of traditional navigation techniques

Here, the main focus is going to be on implementing a mobile application to give a solution to problems discovered from existing traditional techniques. As discussed in the literature survey, today there are so many mobile applications that have already been developed for blind navigation. In order to verify the research gap, let's have a look at what the functionalities of these apps provide to the user and what the visually impaired people’s requirements are still missing from any of these apps. Before that, it is important to mention that these mobile applications were also implemented as a result of previous research. So,

discovering these incomplete requirements simply means identifying the research gap as well.

Products / Features	Blind Square	Lazarillo GPS	Seeing Eye GPS	Google maps	Ariadne GPS	Evelity	Third Eye (Supposed application)
Supports indoor navigation	Yes	No	No	No	No	Yes	Yes
Supports outdoor navigation	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Supports when offline	No	No	No	Yes	No	No	Yes
Record and store the route	No	No	No	Yes	No	No	Yes
Use live view of the map	No	No	No	Yes	No	No	Yes
Recommendation of alternative destinations	No	No	No	No	No	No	Yes
Variations of the voice assistant	The voice assistant can be customized by selecting languages and changing the speed of the way it speaks						Yes

Table 1.3: Comparison of existing navigation mobile applications for blind people

More than that, some mobile applications like "Be my eyes" allow volunteers to register with the system to help visually impaired people. As just an example, if a blind person wants to know where he or she stands right now, they can take a video call to any available registered user. Via the video call, the user can guide the blind person by providing necessary information. There are millions of volunteers who have registered for this app as a social service [30]. But again, there can be conflicts when the user doesn't know the exact details of a particular location, and again, this app also depends on the network as well.

1.3 Research Problem

By looking at the information in Table 1.2, it clearly indicates that, even though there are so many effective smart systems for blind navigation, most of them have some drawbacks. When it comes to smart glasses and smart canes, they meet the majority of the navigation needs of blind people [26][27]. But considering their prices, they are very expensive and can't be afforded by a normal person. And also, these products are not available in third-world countries. When repairs are needed, sometimes the necessary parts can't be found easily. When in rainy, muddy, and dusty weather conditions, this kind of sensitive equipment can be broken [26]. So, the maintenance is a kind of tedious task. Sometimes the camera doesn't give accurate information if there's no considerable light to capture the surroundings [26]. And also, because it mainly depends on the network, in covered indoor areas the devices can't provide data quickly because of the delay in signals [31].

According to the research, blind people don't like to depend on systems that give them commands via vibrations, alerts, and different sounds. At least they don't like to hear the same voice pattern as the voice assistant. Some users want to hear different kinds of voices according to their mood as well, such as happy, encouraging, thrilling, joyful, and so on. Most of the voice assistants are female. It is especially because the clarity, intensity, and understandability of female voices are higher than male voices. But they prefer to hear both female and male voices regardless of age [32].

Depending on the guide dog brings the user much comfort and security, especially in crowded places. However, some places prohibit dogs from carrying like restaurants, hotels, and airplanes. In that case, after reaching these kinds of places, the user again has to rely on any other option. And also, looking after a guide dog is another tedious task. Because the dog is a living being, the user must consider its feeding, health, and sanitation [22].

And also, the tactile paving and tactile maps are not practical for every location. Most of the time, tactile maps are created for public places like libraries, airports, and universities, etc. Apart from that, tactile paving can commonly be used in public pedestrian areas only [24][25].

A human assistant is the easiest and most reliable way for blind people to get around for their navigation purposes. The disadvantage of depending on a person is that human assistants are not working for free. They should be paid. According to previous research, most blind people's opinion is to not depend on a human assistant because they think it is

a kind of bother to them [23]. And also, they want to see and adapt to the world by themselves.

Some blind people said that they wanted to keep their hands free. Holding an external piece of equipment while navigating is inconvenient because their hands are unable to do anything else [14][33]. So briefly, none of the existing physical products or techniques could fulfill 100% of the user requirements of blind people for navigation.

According to the information described so far in the background and research gap sections, a few major issues can be identified. The below survey result, which was conducted on the use of ICT students among 81 smart phone users, represents the features that should be modified in the blind navigation app and confirms the problems that were discovered from the above-mentioned details [34].

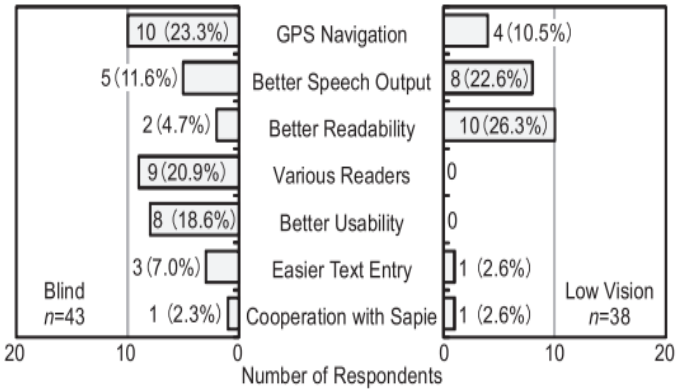

Figure 1.6: Features to be modified in blind navigation apps

Out of 43 responses of blind people, 10 people are requesting for GPS navigation, The second majority 20.9% people are requesting for a diversity in voice assistants. And 18.6% of people are fond to have a better usability such as the app should be work when in offline, there shouldn't be latency of the output so on.

Some people say Google Maps can be edited by anyone by entering wrong location details or renaming or removing existing location names without anyone's permission. Due to that, there can be confusion even for healthy people when finding a destination. On the television and newspapers, there is so much news regarding the accidents that happened because people believed in the Google map too much [35][36]. So, it is much better to have a comparison between the map and the actual environment when navigating to a certain destination.

Considering all the information gathered so far, major problems were identified in the navigation mobile applications for visually impaired people.

- Even though so many apps support outdoor navigation, there are very few for indoor navigation.
- Most applications do not work indoors due to the destruction of network signals.
- Apps don’t work when offline.
- Do not record or save the most frequently used routes.
- No suggestions for similar destinations.

As the sub-requirements below were identified.

- There are no variations or diversity in the voice assistant.
- Most applications do not work indoors due to the destruction of network signals.
- Complexity and challenges in adapting to the application

This study is hoping to create a mobile application called "Third Eye" to help visually impaired people with daily tasks without the need for outside assistance. And also, as Table 2 has shown above, via this application, the developers are planning to provide all the solutions. Therefore, the lack of a better mobile application for the visually impaired can be avoided.

2. OBJECTIVES

Main objective of the whole “Third Eye” mobile application:
Implement an application that can guide and assist blind people and visually troubled individuals. They can have support in which areas they have difficulties. Their difficulties can be overcome by this system which is fully automated with a built-in voice assistant and utilities that can support each of these said groups.

2.1 Main Objective

Main objective of this component:
Implement real time map navigation with a voice assistant support and suggestions to navigations where the distance can be reduced.

As discovered in the research problem section, a mobile application should be implemented for visually impaired people to navigate both indoor and outdoor locations, even if the app is offline. For that objective, live data should be captured and processed, reducing the time delay as much as possible. To be effective on offline platforms, the app should store frequently used routes in an offline database. If the user doesn’t have an exact idea about where to go (as an example, to buy bread, the user can go either to the bakery or a supermarket), the voice assistant should suggest similar destinations according to the ascending order of the destinations. The voice assistant should be triggered quickly for the key words to be more effective. Until the user comes back, this navigation part should be working properly and timely to give a safe and comfortable journey to the user.

2.2 Specific Objectives

In order to reach the main objectives, the specific objectives that needs to be attained is follows,

1. To navigate both indoor and outdoor even offline
   If the user hasn’t been to the particular destination before, for that moment, the app uses Google Maps Street View while comparing the live view. Parallelly, the app records the live video, which is captured from the phone camera, and at the end it asks the user if they need to save it or not. If the user says yes, the particular route details should be

saved in the offline database. When the second time the user goes to that destination, like the first time, the user can use online Google Maps Street View and live view options. Or now the user can use the offline stored route as well. Because of that weakness of the network signals won't be a problem anymore. This can be very effective for both indoor and outdoor navigation.

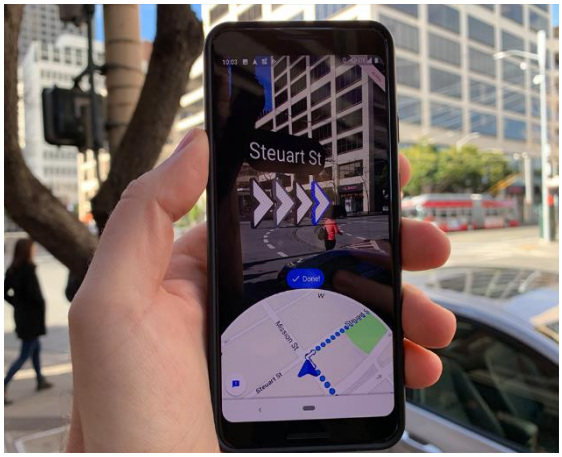

Figure 2.1: Google Maps Live View

Figure 2.2: Google Maps Street view

2. To suggest similar destinations and calculate the time to reach the destination
   Normally, blind people don't have a better understanding of everything. So, if the user says, "I want to go to the Keells supermarket," it is easy to setup the shortest route and calculate the time to the destination. But if the user says "I want to go to the supermarket" instead of mentioning a specific supermarket, this app suggests similar destinations according to the ascending order of the distance. (Cargills 0.5km, Arpico 1km, Keells 1.5km). According to the user's selection, the reaching time should be calculated considering the user's walking speed. Finally, the voice assistant should be triggered to finish the journey or to be prepared for other user needs if the user comes to the selected destination.

3. To be effective, clear, and accurate when the voice assistant guides the user
   The user should be able to customize the voice patterns of the voice assistant according to the user's mood and preferences. It can be the joyful voice of a child, the kind voice of a woman, or the thrilling voice of a man, and so on. By reducing the delay as much as possible, the voice assistant should be able to guide the user even in offline situations. Like the specific route can be stored, the voice directions for that route should also be

stored. The voice assistant shouldn’t disturb the user in crucial places like junctions, pedestrian crossings, and so on.

4. To reduce the complexity and challenges when adapting to the application
   Simple finger commands like swiping and tapping should be implemented as the user can easily use them. Simple voice commands can also be considered to trigger the voice assistant. Before the user goes outside, small areas like home gardens or neighbors’ homes can be used as the areas for practicing purposes. If the user achieves basic levels, the app should suggest advanced routes to follow step by step. Until the user gets confident about them, practice sessions can be conducted. After that, the user can have a safe journey throughout the whole time with "Third Eye."

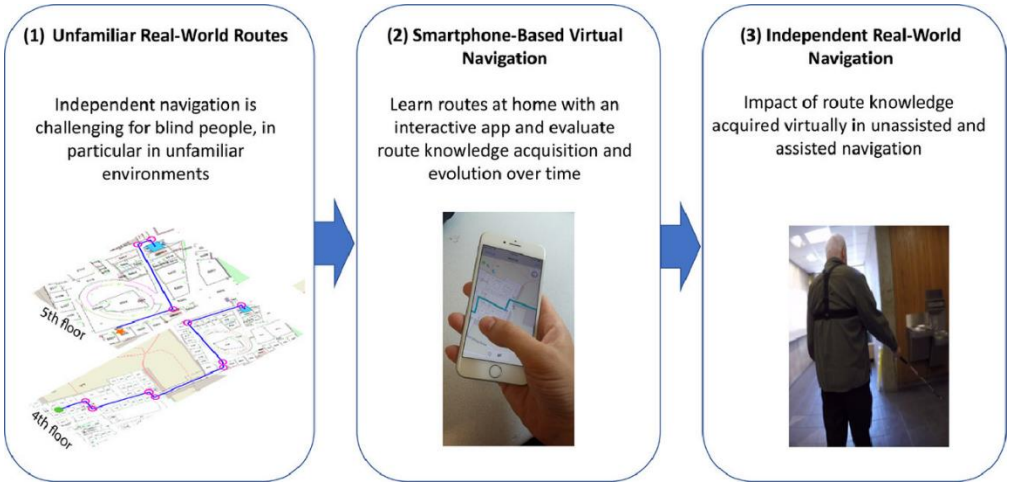

Figure 2.3: How does the user get familiar with the app after the training

3. METHODOLOGY

In order to implement this map navigation function, the below requirements should be correctly developed. And also described in objectives, all specific objectives are connected with each other to achieve the main objective. So, depending on the accuracy and effectiveness of them, issues with existing navigation apps for visually impaired people will be solved in “Third Eye” supposed system. Below are the features in that is going to be covered in the navigation part.

- Both video and voice direction data for the frequently used routes should be stored in the offline database.
- They can be used both indoors and outdoors, even if the app is offline.
- The live view should be compared with the street view in parallel.
- The voice assistant should be customized.
- Finger commands and voice commands should work properly and should be triggered as much as possible when the user requests them.
- Similar destination suggestions should be made according to the key words.
- Reaching time should be calculated approximately correctly considering the user’s walking speed, distance, and also the delays.

When the navigation process starts from the user's registration, it doesn’t allow the user to use the app without a training session. Starting from this training session, let’s have a look at the main procedure of this function.

- Users sign up for the system.
- Starting from the basic level to the advanced level, the system suggests practice sessions for the user to become familiar with the app.
- After the user comes to the expected level, they can select any route to navigate.
- If this is the first time a user has taken this route, both Google Maps Street View and live view comparison help the user until the destination.
- The voice assistant gives the directions the whole time and the camera records the route.
- If the user comes to the destination, the system can suggest similar locations or end the journey according to the user’s preferences. And also, users can allow the system to save the route.

- If a user has already come to this route, the system can again use live and street view comparison or saved route data.

To get a clear idea about how this component works, let's look at the architectural view and technological possibilities.

3.1 Overall System Architecture

The "Third Eye" mobile application consists of four major components. One of them is for people who are suffering from color blindness. In that function, a filtering option is implemented as the users should be able to see the actual colors of images and also in live videos like a healthy person sees. The other three components are for people who are totally blind. As described so far, this part focuses on navigation. Parallelly, the voice assistant and time-calculating parts should be worked on. Another member is implementing the obstacles and road sign identification part. The voice assistant's assistance is needed for this part as well. And also, here the distance to the particular object is calculated considering the phone camera angle and the height of the object. It helps blind users have a safe journey by avoiding objects in their route. Another member is implementing text reading and read aloud functionalities. and also, text translation techniques as well. This app provides the facilities for users to be notified about the weather forecast. Here too, the voice assistant says something about the captured texts and also the weather condition.

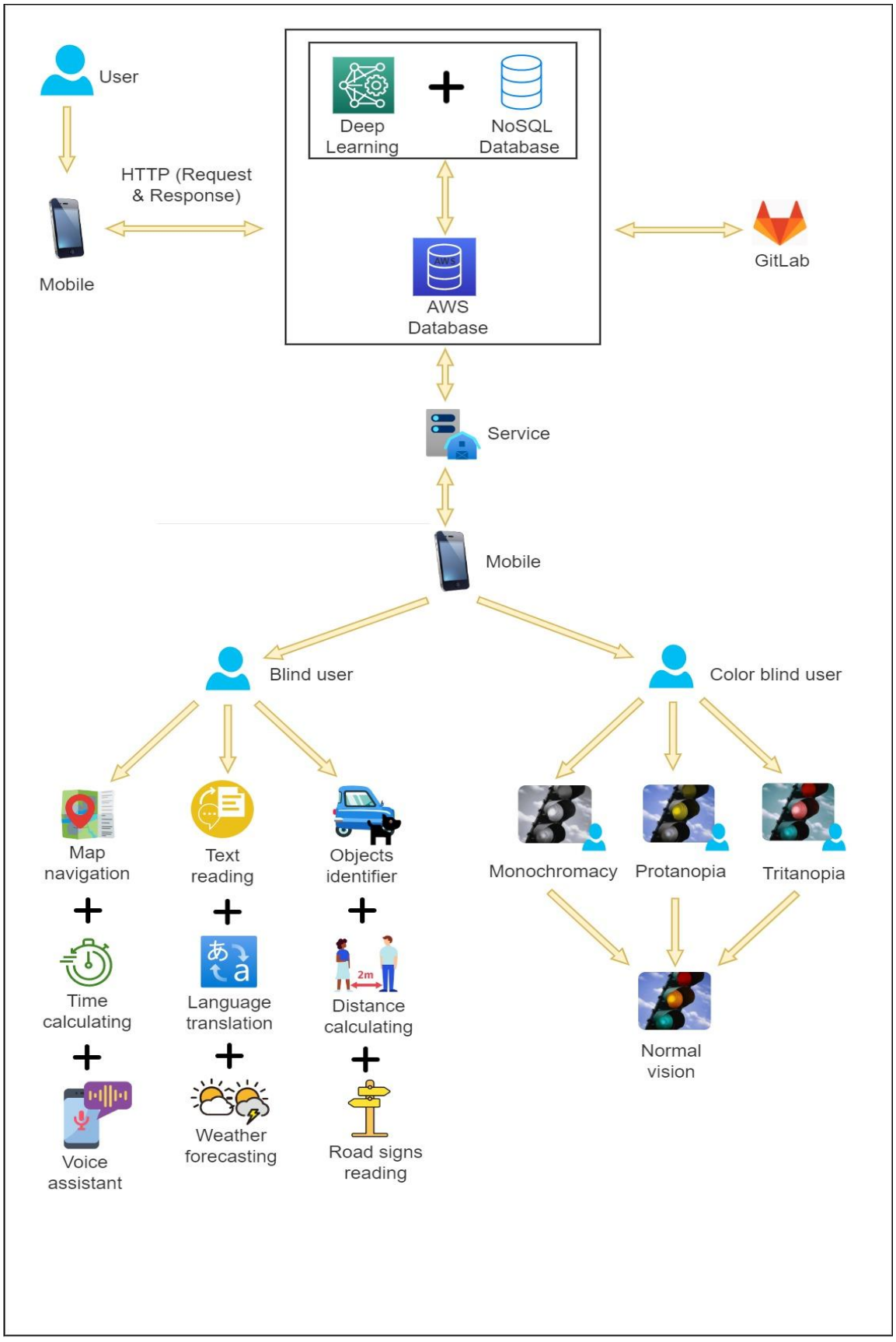

Figure 3.1: Overall system architecture diagram

3.2 Component Architecture Diagram

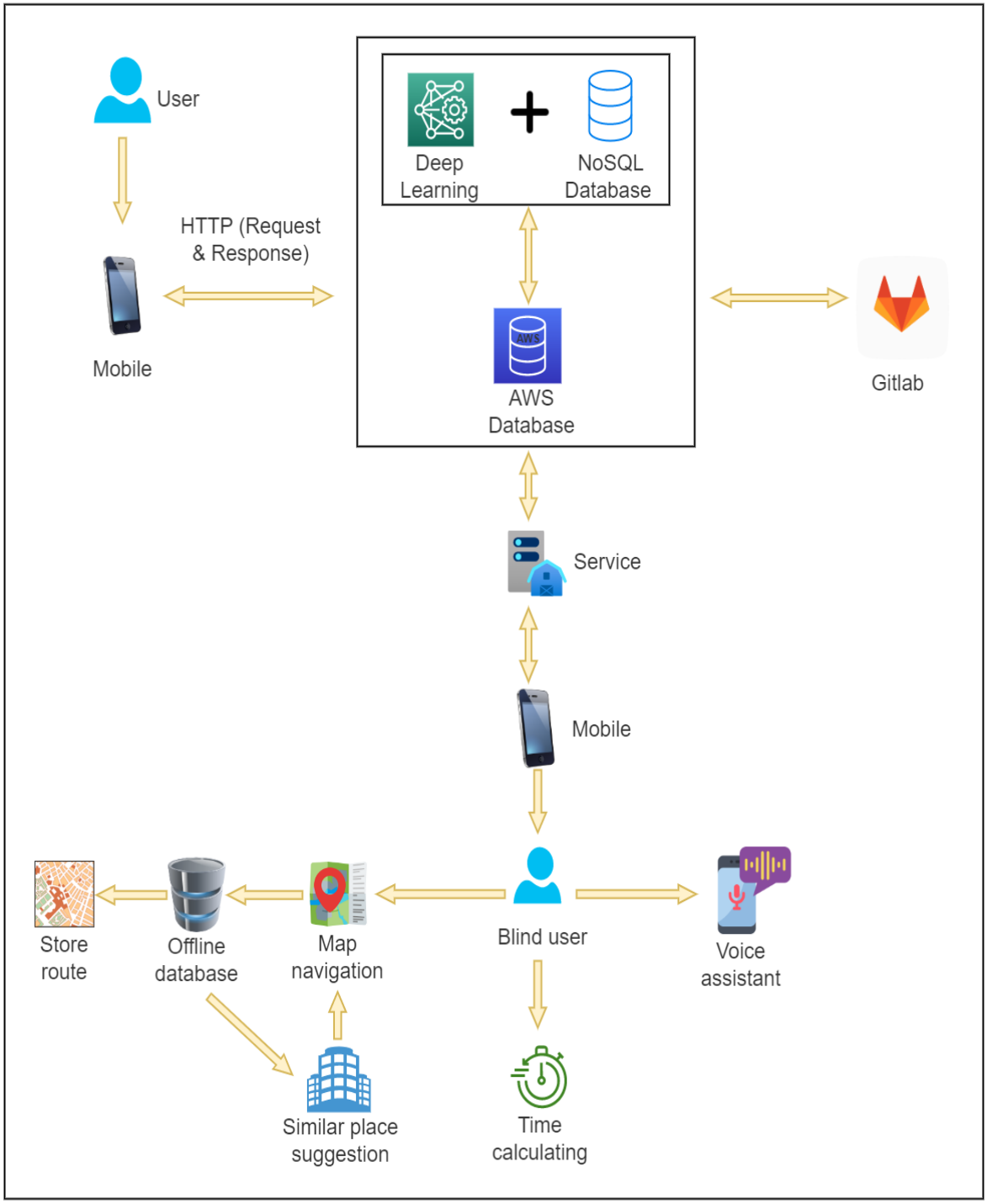

Figure 3.2: Component architecture diagram

3.3 Hardware Solution

When considering the usability of this application, it gives the user a hands-free experience. The app totally relies on the phone's back camera. The user has to keep the phone at least above the stomach level. The user can use a code to hang the phone around their neck or keep it in their shirt pocket (this solution is better for men). This app totally depends on the data capture through the phone camera, so it is a must to keep it where the data can be gathered easily.

The user can directly listen to the phone's speakers to hear what the voice assistant says, and also the user can directly speak to the phone's microphone to give voice commands. But it is recommended to use a handfree, or a headset, to be more convenient, especially in crowded and noisy places. They can be both wired and wireless (Bluetooth). These are the only pieces of hardware that the user should have when using this mobile application. It gives the user a cheap, hands-free, easy experience.

Figure 3.3: Using a code to hang up the phone

Figure 3.4: Bluetooth headset

Figure 3.5: Handsfree

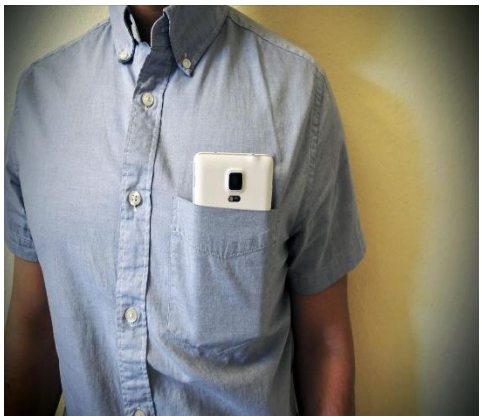

Figure 3.6: The phone in the shirt's pocket

3.4 Software Solution

Agile is a methodology, a framework that allows those using it to adapt and be more productive when it comes to creating and testing their product. Using Agile methodology, a product is developed and tested simultaneously, as opposed to older project management methodologies, such as Waterfall. This methodology requires extensive planning beforehand, as well as very careful planning while doing any alterations to the final product. Because it's a very detailed project management methodology, it's clear that one change can set the whole project back, compromising the quality of work of the teams and their delivery deadlines as well. Scrum, as mentioned earlier, is one of the many Agile project management methodologies. It is widely used, especially when it comes to managing a software development project. Also, unlike more traditional project management methods, scrum is the one that encourages teams to learn as they go, rather than wait for the plan to either work or fail and then have to revisit their mistakes after missing the end goal. Considering this concept, "Third Eye" mobile application is going to develop following Agile methodology.

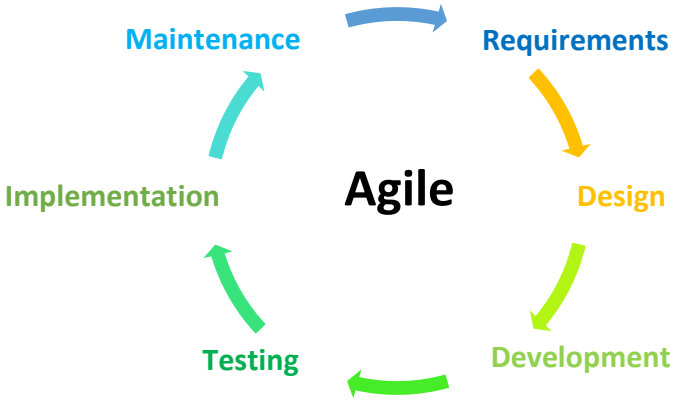

Figure 3.7: Agile development cycle

- Requirements gathering and analyzing

  To gather the requirements, "The School for the Blind" in Rathmalana was selected. To reduce the conflicts or mismatches in their needs, it is better to collect at least 50 samples. The sample should consist of both male and female participants regardless of age. And also, to come up with this project proposal, survey results of blind navigation, which were conducted for the visually impaired people in some countries, were gathered. These details are already mentioned in the previous pages.

Schedule feasibility – This navigation component should develop within the given timeline because the other two functions are mainly dependent on its functionalities.

Economic feasibility – The cost should be calculated at the beginning of the planning. Some plugins, libraries, and tools for map navigation are not free to download from the internet. So, it is necessary to buy them for an affordable price. Because there's no external equipment to buy, this product can be implemented with less expenditure. But for the cloud platforms or site visits, it will be a little costly. However, it is unable to predict exactly what future expenditures will be. Therefore, it is safe to come up with a budget plan.

Technical feasibility - Selected tools and technologies should be supported to develop map navigation. It is needed to verify that this component can be implemented without having conflicts with other components. GPS is the main thing this map navigation function relies on. With a phone's sensors and GPS data, a navigation app knows how fast the user is moving. The user's movements won't affect to the efficiency of data collection. If so, then can utilize the stabilization options to make the live video more stable. And also, this part should be adapted to work both on online and offline platforms. So, the network and technical feasibility should be of great concern. The data refresh rate should be quite fast. Otherwise, the system won't be able to give certain location data on time. Otherwise, the system won't be able to give certain location data on time.

- Implementation

  The implementation phase complies with the development of the functionalities below.

  - Implementation of both indoor and outdoor navigation using the Google Maps Street View and live view.
  - Implementation of the customized voice assistant with clear instructions.
  - Storing the frequently used route data to the offline database.
  - Implementation of the similar places suggestion.
  - Implementation of the time and distance calculation.
  - Optimal data capturing and processing.
  - Computer vision.

3.5 Requirements

3.5.1 User requirements

- User should be registered to the system.
- User's data privacy should be protected and safe.
- The application should be easily handled by the user.
- The app should be capable to assist the BVI throughout routes that combine both pedestrian and navigation and navigation by any other means of transport.
- The app should be capable to detect a wrong route and to correct or adjust it accordingly.
- It is desirable that the app could manage multiple destinations or stops along a route.
- The app should provide real-time information without any latency.
- The BVIs should be able to set the destination on their own (the autonomy and independence of the BVIs is very important).
- As far as outdoor navigation is concerned, it would be desirable that the app provides a list of favorite destinations that the BVI can edit.
- The BVI should have the ability to dictate the destination address on the device.

3.5.2 System requirements

- System should be applicable for full blind and color-blind people.
- Proposed mobile application should work on both Android and iOS mobile operating systems.
- In general, however, other applications (including the voice assistant) should be able to run in parallel with the navigation app.
- GPS should be discreet and not too obvious.
- Any GPS device must refresh the information it provides at high frequency because some BVIs can move at a fast pace.
- Stored route and voice direction data should be work properly on offline status.
- Smartphone should have at least a 20MP back camera which all of modern smartphone have these days.

3.5.3 Non-functional requirements

- Availability

- Reliability
- Security
- Speed
- Accuracy
- Maintainability
- Usability
- Performance

3.6 Tools and Technologies

- Cross Mobile Platform Development

  The final product contains both iOS and Android application to support cross mobile platform support. To achieve this using flutter is the best framework which supported by google. Which has an array of updating and a variety of UI library support which enables smooth UI/UX for users. Open-source framework and the base OS of the framework is Dart which is not used that much for web development but since the time of flutter came to the mobile application development it became famous.

- Database Handling

  The application will generate thousands of data when the user is using or for processing. Best option is to use NoSQL database which lets handle big data. Amazons DynamoDB is the database we will use for the system. Handling CRUD operations as well as authorization operations will be easy to implement with a built-in security by Amazon Web Services.

- Version Controlling

  When creating an application which handles a vast area of code bases and changes each and every day also improvements can be happening when an existing method can have a more simplistic and secure way to handle. When this happens versioning and keeping a track on code base is a must. For that Git is used.

- Keras & Tensorflow

  Keras is the high-level API of TensorFlow 2: an approachable, highly productive interface for solving machine learning problems, with a focus on modern deep learning.

It provides essential abstractions and building blocks for developing and shipping machine learning solutions with high iteration velocity.

Keras empowers engineers and researchers to take full advantage of the scalability and cross-platform capabilities of TensorFlow 2: you can run Keras on TPU or on large clusters of GPUs, and you can export your Keras models to run in the browser or on a mobile device.

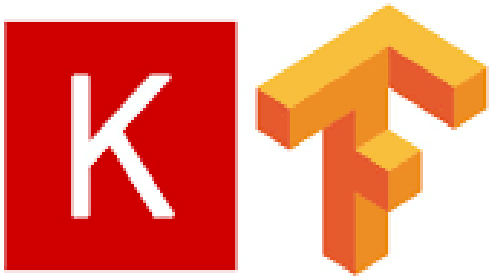

Figure 3.7: Keras and TensorFlow

- OpenCV

  The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc. This will help us when using camera of the mobile phone.

Figure 3.8: OpenCV

4. EVALUATION CRITERIA

4.1 Gantt Chart

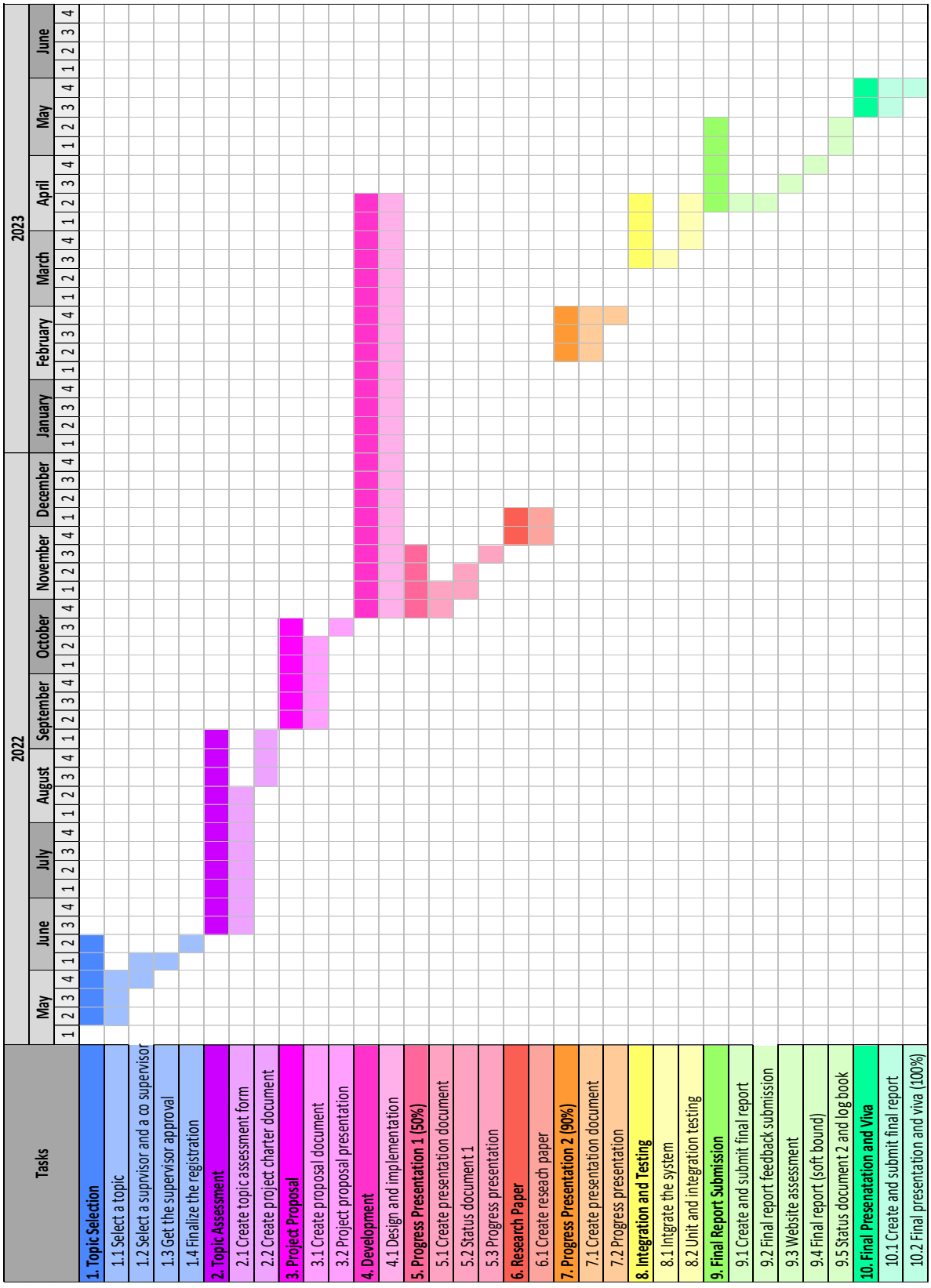

Figure 4 1: Gantt Chart

4.2 Work Breakdown Structure

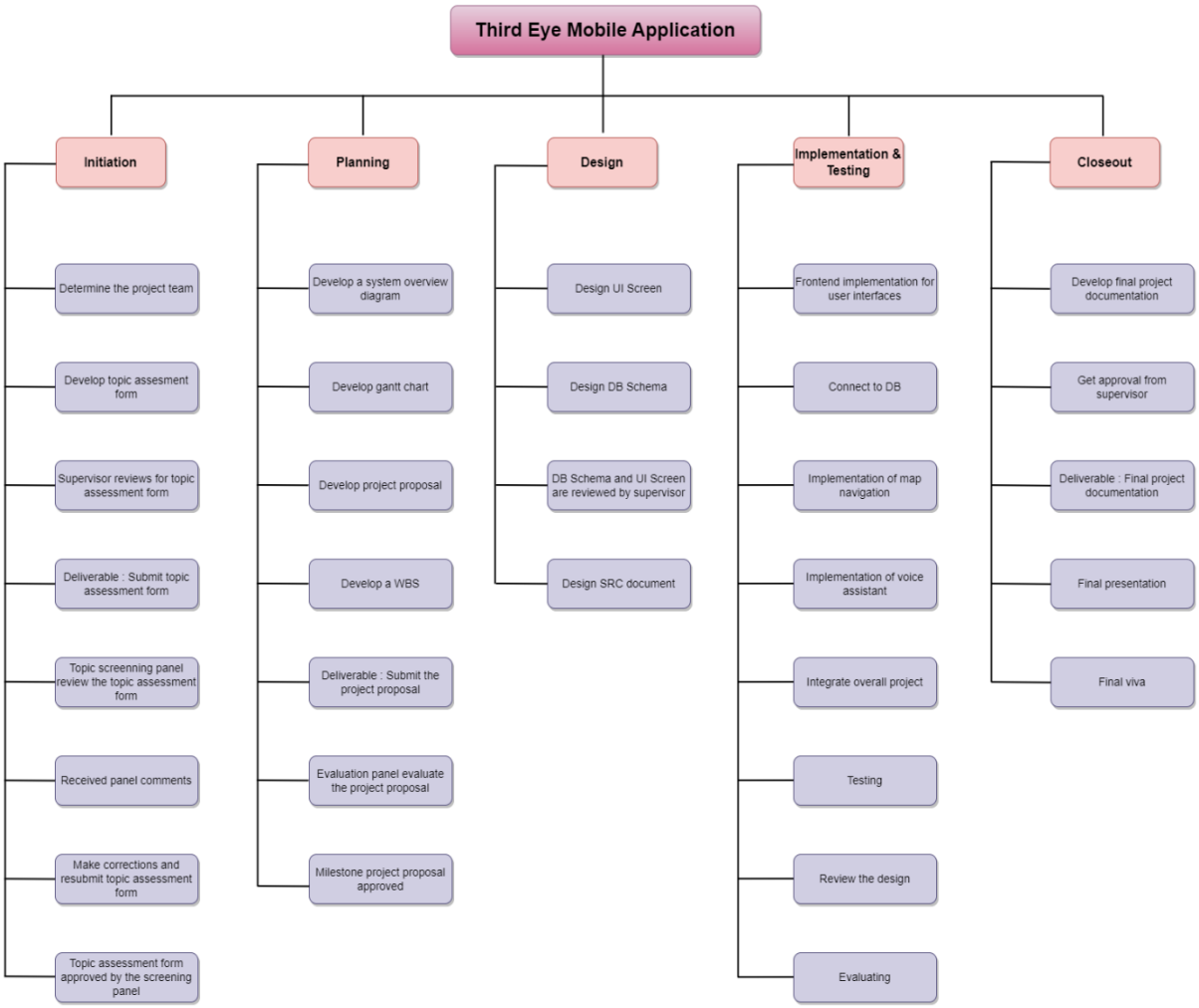

Figure 4.2: Work breakdown structure

5. BUDGET AND BUDGET JUSTIFICATION

Component	Amount (USD)	Amount (LKR)
DynamoDB ($24 per month)	288.00	110000.00
EC2 (PAYG for 750Hrs)	77.00	29000.00
Phone lanyard strap	3.00	750.00
Site visits and transport	9.00	3000.00
Document printing	28.00	10000.00
Total	**$ 405.00**	**Rs. 152750.00**

Table 5 1: Budget plan

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