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Final Project Thesis – Individual

MOBILE BASE SINHALA BOOK READER FOR VISUALLY IMPAIRED INDIVIDUALS - OPTICAL CHARACTER RECOGNITION (OCR)

by

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9/10/2023

DECLARATION

To the best of our knowledge and belief, this proposal does not contain any previously published or written material by another person, except where the acknowledgement is made in the text. I hereby declare that this is my own work and that no material previously submitted for a degree or diploma in any other university or Institute of higher learning has been incorporated without acknowledgement.

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

....09/10/2023...................

Signature of the supervisor Date

ABSTRACT

The Android-based mobile solution developed for this study aims to satisfy the community of blind people's specially visually impaired children's reading requirements. The project aims to provide a replacement for the obsolete readers for printed Sinhala story books. This was created especially for blind children. The Optical Character Recognition (OCR) synthesizer's simplicity can be further improved by adding the prosodic features' correctness to the voice. A user with vision impairments can easily utilize the book reader on their smartphone by using physical signals and the audio-based support incorporated into the picture collecting module. Reading is an essential skill for people to learn information for the majority of their everyday jobs.

As my part, I will be doing the Optical Character Recognition (OCR).Optical Character Recognition (OCR) technology is a tool that can be used to help blind and visually impaired people access printed text. OCR software can analyze images or scanned documents and extract the text from them, which can then be read aloud by a text-to-speech program. OCR technology can also be used to convert printed books, articles, and other documents into accessible digital formats such as e-books or audio books, which can be easily accessed and navigated using assistive technology .The optical character recognition (OCR) component is a key feature of the mobile-based Sinhala book reader for visually impaired individuals. This component allows the user to take a picture of a printed, typed text and convert it into machine- encoded text that can be read aloud by the app. OCR is the process of identifying and classifying optical patterns in a digital image and translating them into machine-readable text. The OCR component of the app uses advanced algorithms and image processing techniques to extract text from an image, such as a page from a book or a newspaper.

The extracted text is then processed and converted into an electronic or mechanical format, which can be played back on a screen or read out via the text-to-speech function of the app. By enabling access to a variety of Sinhala literature for people who are blind or visually impaired, this component supports the Sinhala language.

By incorporating OCR technology into the mobile-based Sinhala book reader, visually impaired individuals can now access printed materials with ease, promoting their independence and enhancing their reading experience. The OCR component is a critical feature that enables users to access and enjoy a wealth of literary resources that were previously inaccessible to them.

Optical Character Recognition (OCR) technology can also be used for Sinhala character identification and word formation. OCR software can analyze images or scanned documents containing Sinhala text and extract the text from them, which can then be used for further processing. With the help of machine learning and image processing, OCR technology can be trained to accurately recognize Sinhala characters. This can greatly improve access to Sinhala literature and other printed materials for blind and visually impaired individuals who use assistive technology.

In conclusion, the Android-based mobile solution developed for this study represents a significant step forward in addressing the reading requirements of the blind and visually impaired community in Sinhala-speaking regions. By integrating advanced Optical Character Recognition (OCR) technology, the initiative offers a transformative alternative to outdated printed document readers, making it possible for individuals with vision impairments to access a vast array of literary resources and printed materials effortlessly.

The incorporation of prosodic features further enhances the naturalness of the OCR synthesizer's voice, ensuring a more immersive and engaging reading experience. Additionally, the integration of haptic signals and audio-based support within the picture acquisition module empowers users to navigate the book reader application seamlessly on their smartphones. Through the OCR component's ability to recognize and translate Sinhala characters, the technology not only promotes independence but also opens up new possibilities for visually impaired individuals to engage with Sinhala literature materials. In essence, this mobile-based Sinhala book reader not only fosters accessibility but also enriches the lives of those with visual impairments, reaffirming the vital role of reading as an essential skill for acquiring knowledge in daily life.

The Android-based mobile solution we've created is like a magical book for kids who can't see very well. It's designed just for them, so they can enjoy wonderful stories in Sinhala, just like their friends. We wanted to make sure they have a special way to read, and this is how we did it: Imagine you have a talking friend who can read any book to you. This friend can even make the stories sound exciting and fun, like when your teacher reads in school. We made sure that this talking friend can also understand Sinhala really well, so you can listen to stories in your own language.

But that's not all! We added some special tricks to make reading even more fun. When you touch the pages on your phone, it feels like you're touching the words in the book. Your phone can also talk to you using sounds and vibrations, so you can explore the stories with your fingers and ears.

My part in all of this is like having super-smart eyes for your phone. You know how your eyes can see letters and words? Well, I taught your phone how to do the same thing! When you show your phone a page from a book, it can read the words and tell you the story. It's like having a magical reading helper in your pocket. We even taught your phone to recognize Sinhala letters really well. So, if you have a special book with Sinhala letters, your phone can read it too! This way, you can enjoy lots of different books, not just the ones in regular print.

In the end, our special mobile solution is here to make sure you can enjoy stories just like all your friends. With our magical talking friend and smart eyes for your phone, you can read and have fun, even if your eyes don't see so well. Reading is an amazing way to learn and have adventures, and we're here to help you on that journey.

ACKNOWLEDGEMENT

First and foremost, I'd like to thank Prof. Koliya Pulasinghe, my supervisor, and my co-supervisor Ms. Poorna Panduwawala . I'd like to thank all of the teachers and staff at the Sri Lanka Institute of Information Technology. Also I want to thank my group members as well.

I am honored to have contributed to the development of the Android-based mobile solution described above, designed to provide visually impaired children with an enchanting and accessible reading experience. My role in this project involved the implementation of the Optical Character Recognition (OCR) technology, a crucial component that allows children to explore the world of stories in their own unique way. I would like to express my sincere appreciation to the children who became the inspiration for this project. Your unwavering curiosity and enthusiasm have been the driving force behind our efforts to create a tool that empowers you to explore the wonders of literature .I am deeply grateful for the collaboration and support of the talented team of researchers, developers, and educators who shared their expertise and passion, making it possible to turn this vision into reality. Furthermore, I extend my thanks to the organizations and institutions that provided the resources and guidance necessary to bring this project to fruition. Your commitment to enhancing the lives of visually impaired children through technology is commendable. Lastly, I am thankful for the wider community that recognizes the importance of making literature accessible to all children, irrespective of their visual abilities. It is through collective efforts that we can enrich the lives of young readers and foster a lifelong love for learning. In contributing to this project, I take pride in knowing that we have made a positive impact on the lives of visually impaired children, offering them a unique and magical journey into the world of stories.

Executive Summary

The Mobile-Based Sinhala Book Reader for Visually Impaired Children is an outstanding example of creativity, usability, and the transformative potential of technology in tackling a significant societal issue. By removing the challenges that have historically prevented visually challenged students in Sri Lanka from accessing the world of Sinhala literature and education, this innovative application serves as a symbol of hope. Its specific goal is to empower kids who are blind. The primary component of the software, Sinhala Text-to-Speech (TTS), enables seamless translation of Sinhala text into clear and understandable audio, radically changing the learning environment for children with visual impairments. But to further serve people who prefer physical reading, it easily works with blind displays as part of its dedication to variety. The user interface, characterized by its intuitive design, voice-guided menus, sizable buttons, and adaptable settings, ensures that accessibility remains at the forefront of the user experience. The expansive library of Sinhala content, meticulously curated to span a diverse array of subjects and genres, promises to enrich the educational journey of visually impaired children, serving not just as a tool for literacy but as a gateway to the worlds of knowledge, imagination, and exploration. Acknowledging the constraints of connectivity, the app offers offline access, ensuring uninterrupted learning regardless of internet availability. In a bid to foster comprehension and engagement, the app introduces multi-modal learning elements such as interactive quizzes, voice notes, and tactile activities, underscoring its commitment to providing not just education but an enriching and enjoyable educational experience. In a nation where visually impaired children face limited access to educational materials in their native language, this application is poised to make a profound impact, elevating literacy rates, promoting inclusive education, nurturing independence, and actively contributing to digital inclusion. The revenue model, a strategic blend of freemium offerings, partnerships with educational institutions, and solicitations of donations and grants from governmental and non-governmental entities, not only ensures the sustainability of this initiative but underscores its commitment to making quality education accessible to all. In essence, the Mobile-Based Sinhala Book Reader for Visually Impaired Children transcends being a mere technological advancement; it symbolizes a collective commitment to building a more equitable and inclusive society where every child, regardless of visual impairment, can embark on the enchanting journey of reading, learning, and realizing their fullest potential. Investment in and support for this

project are not just investments in technology; they are investments in the future of visually impaired children in Sri Lanka and a testament to the profound impact that innovation, inclusivity, and education can have on society.

List of Abbreviations

OCR – Optical Character Recognition

TTS – Text-to-Speech

NLP – Natural Language Processing

API – Application Programming Interface

ML – Machine Learning

CNNs – Convolutional Neural Networks

WCAG – Web Content Accessibility Guidelines

UI – User Interface

AI – Artificial intelligence

ANN – Artificial Neural Network

MLP – Multi layer perceptron

2DFFT– 2D Fast Furrier Transform

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Chapter 01
INTRODUCTION

Figure 1:OCR

The inability of visually impaired people to accurately recognize physical items, their precise location, and their precise size puts them in difficult situations on a daily basis. The bulk of the solutions proposed in this situation include speech recognition as one of the more effective methods of item identification as the community of visually impaired persons can comprehend audio with ease. Portable solutions are frequently made in computing technology to answer the aforementioned problem, which is unquestionably an advancement. In this case, it has provided motivation for the development of more mobile applications that efficiently assist users who are blind or visually impaired. An alternative viewpoint or method to incorporate into the answer through clever software development that uses computer vision as an eye for this group and makes life easier for them in day-to-day duties would be the aiding approach.

When we observing about the visually impaired society in Sri Lanka we can come across these details;

The study focused on the 40-year-old population in Sri Lanka to evaluate blindness and visual prevalence. This age cut-off was determined using earlier statistics, which revealed that 75% of blindness and visual impairment occur after the age of 40. The major sampling units were districts. To identify a nationally representative sample, cluster sampling with proportionate to size (PPS) techniques was used. As a result, the more populous districts had a higher number of participants.

The nationally representative sample was large enough to produce estimates for five age groups as well as estimates for each gender. Furthermore, the sample size was enlarged to offer credible estimates for some of the country's larger provinces.

The sample size estimate was based on information from South Asia because Sri Lankan statistics on the prevalence of blindness and visual impairment was insufficient. The following criteria were employed:

Table 1:using parameters for sample size calculation

· Prevalence of blindness (presenting vision) among those aged ≥40 years:	2.5%
· Confidence interval:	95%
· Allowable error:	0.02
· Precision:	80%
· Design effect:	1.5
· Response rate:	85%
· Age strata:	4
· Sex strata:	2
· Residence strata:	2

These criteria led to a sample size requirement of 6,600. This results in an 85% response rate; the percentage was rounded off. This sample would offer precise estimates of the prevalence of blindness and visual impairment at the national level, as well as the main causes of blindness, ocular illness, and disability in people under the age of 40.

Table 2:Comparison of Human Development Indicators in some South Asian countries

Country	HDI value in 2013	HDI rank	Life expectancy at birth	Mean years of schooling	GNI per capita (US$)
Sri Lanka	0.750	73	74.3 years	10.8 years	9250
India	0.586	135	66.4 years	4.4 years	5150
Pakistan	0.537	146	66.6 years	4.7 years	4652

Ref: UNDP Human Development Report 2014 [1].

In a world increasingly driven by technology and innovation, it is our moral duty to ensure that every child, regardless of their abilities, has access to the magical world of literature. In the beautiful island nation of Sri Lanka, this commitment to inclusivity extends to the visually impaired children who, despite their challenges, are just as deserving of the joy and wonder that reading can bring. Enter "Audio Sight " – a groundbreaking online storybook reader app, thoughtfully designed to open the doors of imagination and knowledge to visually impaired children across Sri Lanka. An innovative online storybook reader programmed called "Audi Sight" was carefully created to empower young Sri Lankans who are blind or visually impaired. With a simple and user-friendly interface that allows even the youngest users to autonomously explore their beloved stories, this digital refuge serves a broad age spectrum, from the youngest of toddlers to the blossoming adolescents. An enormous collection of varied audio books that have been painstakingly chosen to feature tales from a wide range of countries, genres, and languages make up the core of this application. "Audio Sight" cultivates an awareness for the various viewpoints that stories from around the world give in addition to igniting a love of reading.

Imagine a world where a child's dreams can take flight on the wings of words, where the limitations of sight fade away in the presence of a good book. That is the vision behind "Audio Sight ". In Sri Lanka, as in many parts of the world, visually impaired children face unique challenges in accessing literature and learning. Most sighted children take for granted the lack of braille books, the expensive expense of specialized tools, and the dearth of resources for braille instruction as barriers to literary research. This outstanding application goes beyond simple passive listening. Through interactive features like touch-screen gestures and aural feedback, it turns reading into a thrilling journey. Every contact in "Audio Sight" offers a chance for participation and education. Additionally, the program exemplifies personalization by adapting its content to each child's own reading abilities and preferences. It provides personalized book suggestions, monitors reading progress, and acts as an amazing instructional tool to help students build critical literacy skills.

But "Audio Sight " is here to change that narrative. This revolutionary app is not just another tool; it's a beacon of hope and an embodiment of the belief that every child, no matter their visual abilities, should have the same opportunities to learn, grow, and be inspired by the magic of stories.

"Audio Sight" is a ground-breaking online storybook reader app created to empower visually challenged children in Sri Lanka. It is appropriate for children of all ages, from babies to teenagers, and has a user-friendly layout that allows even the smallest users to actively explore their favorite stories. The app features a large library of diverse audio books that have been handpicked to contain stories from various countries, genres, and languages, encouraging a love of reading and an awareness for different points of view. Enter "Audio Sight" goes beyond passive listening with its intuitive and interactive design, engaging youngsters with touch-screen motions and audio feedback to provide an immersive reading experience. Personalization is central. of "Audio Sight ", as the app adapts to each child's reading level and preferences, offering customized recommendations and tracking progress while providing built-in educational tools. Beyond being an app, "Audio Sight " is a supportive community of families, educators, and volunteers dedicated to nurturing a love for reading among visually impaired children through support forums, book clubs, and resource sharing. Additionally, recognizing the challenges of constant internet access, "Audio Sight " allows users to download books for offline reading, ensuring that the magic of storytelling is always within reach.

In today's fast changing technology landscape, it is critical that innovation serves an important purpose - empowering and providing fair access to information and literature for everyone. This is especially true in Sri Lanka, which is known for its lively culture and rich literary heritage. The commitment to inclusivity extends all the way to the visually challenged community here. "Audio Sight" is a cutting-edge mobile Sinhala book companion that includes Optical Character Recognition (OCR) technology. Sarathi represents our constant commitment to empowering visually impaired people by breaking down the obstacles that have long hindered their access to the world of Sinhala literature

1.1 Research Objectives

The research will be conducted with a focus on Sri Lankans who speak Sinhala as their native tongue. The planned solution system must handle the problem of visually impaired or blind children in Sri Lanka reading story books .In the technological sense of the study's plan optical character recognition (OCR) is the most crucial element .OCR engines use, text preprocessing and character recognition to convert printed characters into machine-readable text. The acquisition procedure involves photographing or scanning the printed area, and preprocessing involves getting the image ready for the right kind of identification. It correctly recognizes the characters or words during the recognition stage. As per the described problem domain, it is evident that a solution to the reading need of the visually impaired or blind children community in Sri Lanka should be addressed. Also, this is focused on addressing the reading needs of visually impaired or blind children in Sri Lanka who speak Sinhala as their native language. The planned solution involves the use of Optical Character Recognition (OCR) technology as a crucial element. Here's more information on various aspects of this research plan:

1. Target Audience:
   The primary target audience for this research is visually impaired or blind children in Sri Lanka. These children face unique challenges in accessing printed material, such as storybooks, which are essential for their education and overall development.
2. Language Focus:
   Since the research is specific to Sri Lanka, it recognizes the importance of catering to the needs of Sinhala-speaking individuals. Therefore, the OCR system will be designed to work effectively with Sinhala text.
3. OCR Technology:
   Optical Character Recognition (OCR) technology is central to this research. OCR engines are software or hardware systems that play a pivotal role in converting printed text or characters into machine-readable text. The process typically involves three main stages: text preprocessing, character recognition, and output generation.
4. Text Preprocessing:
   Preprocessing is a crucial step in OCR. It involves preparing the image of the printed text for accurate character recognition. This includes tasks such as noise reduction, binarization (converting the image to black and white), and layout analysis to identify text regions within the image.

5. Character Recognition:

   Character recognition is the core functionality of an OCR system. It involves the identification of individual characters or words within the processed image. Modern OCR systems use machine learning and pattern recognition techniques to achieve high accuracy in character recognition.

6. Image Acquisition:

   The acquisition procedure in this context likely involves capturing images of the printed material using devices like cameras or scanners. The quality of the acquired images can significantly affect the accuracy of OCR.

7. Community Need:

   The research recognizes the urgent need to address the reading challenges faced by visually impaired or blind children in Sri Lanka. Access to storybooks and educational materials is essential for their intellectual and emotional development. The proposed OCR solution aims to bridge this accessibility gap.

8. Accessibility and Inclusivity:

   The research aligns with the principles of accessibility and inclusivity. By developing an OCR system tailored to Sinhala and optimized for the needs of visually impaired or blind children, it seeks to provide equal opportunities for learning and enjoyment of literature.

9. Future Directions:

   Depending on the research outcomes, there may be opportunities to expand the scope of this project. This could include developing user-friendly interfaces, integrating the OCR system with assistive technologies, or exploring ways to make it accessible via smartphones or other devices commonly used by the target audience.

In summary, the research plan focuses on developing an OCR-based solution to empower visually impaired or blind children in Sri Lanka who speak Sinhala by enabling them to access and enjoy storybooks and educational materials. It acknowledges the critical role of OCR technology in achieving this goal and emphasizes the importance of addressing the unique needs of this community.

1.2 Main Objective

The core objective of this study is to pioneer the development of a speech synthesis system uniquely tailored to cater to the reading needs of visually impaired individuals, primarily focused on Sinhala literature. This innovative system seamlessly combines advanced technologies like Festival and speech tools to facilitate the reading process. It leverages Optical Character Recognition (OCR) to convert physical Sinhala books into a digital format, enabling a crucial transformation. Subsequently, a Text-to-Speech (TTS) synthesizer takes center stage, articulating the written Sinhala text into spoken words, rendering literature accessible and immersive for visually impaired users. Beyond this, the system offers customizable settings, enhancing personalization and comfort in the reading experience. Furthermore, it incorporates audible guidance features, not only simplifying navigation within the application but also providing valuable location information within the book.

In essence, this pioneering speech synthesis system emerges as a vital tool, breaking down accessibility barriers and enriching the world of Sinhala literature for visually impaired individuals, fostering learning, personal growth, and cultural engagement within the Sinhala-speaking community. The study's key goal is to develop a speech synthesis system for visually impaired individuals using festival and speech tools to read Sinhala books. A Sinhala book reader for the visually impaired is a software program designed to make reading accessible for individuals with visual impairments. It combines various technologies to provide a seamless reading experience. The device utilizes optical character recognition (OCR) technology to convert the text from a physical book into a digital format. Then, a text-to-speech synthesizer reads the text out loud in the Sinhala language, making it easier for visually impaired users to follow along. to provide visually impaired individuals with an accessible and convenient way to read Sinhala literature and to enhance their access to literature. The app aims to achieve this by using OCR and TTS technology and providing visually impaired individuals with customizable settings to enhance their reading experience. A Sinhala book reader for the visually impaired is a software program designed to make reading accessible for individuals with visual impairments. It combines various technologies to provide a seamless reading experience. The device utilizes optical character recognition (OCR) technology to convert the text from a physical book into a digital format. Then, a text-to-speech synthesizer reads the text out loud in the Sinhala language, making it easier for visually impaired users to follow along. In addition to the text-to-speech synthesizer, the device also includes audible guidance to help navigate the app and identify the distance to the book being read. This makes it easier for visually impaired users to find their place in the book and keep track of their progress.

1.3 Sub Objective

To accurately create computer-readable text from collected photos using the right image preprocessing. to put in place a Sinhala text-to-speech synthesizer that can translate text into speech. to evaluate the Sinhala language system's effectiveness. Create a user-friendly, accessible interface that is simple to navigate and suitable for those who are blind. Assuring that visually impaired people can use the app on a number of mobile devices requires designing the app to be flexible to diverse device sizes and screen resolutions. Create an OCR engine that can recognize Sinhala letters and convert scanned pictures of Sinhala books into editable, searchable text. By testing it with a blind focus group and collecting feedback, the program might be enhanced to provide a seamless and accessible reading experience for persons who are visually impaired. This complete project combines powerful OCR and TTS technologies with user-centric design principles to provide a platform that is accessible and inclusive for visually impaired individuals'. By addressing the technical intricacies of Sinhala character recognition, enhancing speech synthesis, and actively involving the end users in the testing and improvement process, this initiative endeavors to break down accessibility barriers and provide a seamless reading experience for those who are visually impaired, ultimately promoting literacy, learning, and cultural engagement within the Sinhala- speaking community.

1.4 Structure of the Thesis

- Chapter 2: Mainly in this chapter, some of the already existing models that have addressed similar issues were compared with our solution and the significance of our work was highlighted. A brief overview about Optical Character Recognition (OCR) technology was also discussed. Also the types of requirements have been gathered . Chapter 3 will discuss the software implementation process.

- Chapter 3: This chapter addressed the overview system architecture of the designed work briefly. The individual contribution has been discussed broadly using the technologies used for the software implementations..

- Chapter 4: This chapter aims results and discussions on the project

- Chapter 5: The conclusion of the project is presented in this chapter.

Chapter 02
LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of Optical Character Recognition (OCR) technology and introduces the research gap we're focusing on. Also a brief discussion comparing our designed solution with similar existing projects will be included. Later on this chapter will give the project requirements as well .

2.2 Background & literature survey

Optical Character Recognition (OCR) technology is a powerful tool that can convert images of text into machine-encoded text that can be read by computers [2]. This technology has revolutionized the way we interact with written content, enabling us to digitize printed materials and make them accessible to a broader audience. One of the most important applications of OCR technology is the development of inclusive technology that assists visually impaired people [6]. Using OCR technology, visually impaired people can scan and recognize text from photographs or documents using their smartphone's camera. The text is subsequently converted into spoken language, allowing visually impaired individuals to access and grasp the material. Optical character recognition (OCR) technology has fundamentally altered how humans interact with written content by converting photos of text into machine-readable text. This breakthrough permitted the digitization of printed documents, making them more accessible to a larger audience, and also revolutionized accessibility for visually impaired people in particular.. Individuals with visual impairments can now use the cameras on their smartphones to scan and recognize text from photos or documents thanks to OCR technology. This text can then be converted into spoken words, providing visually impaired individuals with a means to access and comprehend content that was previously inaccessible to them.

Overall, the history of Sinhala OCR technology for visually impaired individuals is a relatively short one. However, with the increasing usage of smartphones and other mobile devices, there is a big opportunity for the development of innovative and novel OCR apps that can considerably improve the quality of life for Sri Lanka's visually impaired people. This offers immense promise, especially considering the growing popularity of smartphones and other mobile devices. With the right applications and advancements, OCR technology can significantly enhance the quality of life for visually impaired individuals in Sri Lanka.

However, most existing OCR programs are designed for English and industrial use, leaving languages like Sinhala underrepresented. [10] Some OCR systems are available in other languages[1] . Developing an OCR application for Sinhala language presents unique challenges, including the complex combination of characters and variations in font styles and image quality. Despite these obstacles, we believe that developing inclusive technology for all people is vital, and we are devoted to providing visually impaired people with the tools they need to access information and improve their quality of life. This report will explore the development of an OCR app for the Sinhala language, including the challenges involved, the potential use cases, and the impact on the lives of visually impaired individuals in the community.

In today's world, access to information is crucial for personal growth, education, and career development. Unfortunately, for visually impaired individuals, accessing printed materials can be a significant challenge [14] . OCR technology offers a solution by providing a means to convert printed materials into digital text that can be accessed using assistive technologies such as text-to- speech readers.

When it’s come to the Tesseract OCR. Existing Tesseract OCRs are common in to the society. Tesseract expects a binary image using optional polygonal text regions as data. Tesseract is language-independent and its initial objective was to identify white on black. This resulted in the design using associated parts evaluation and working on part outlines.

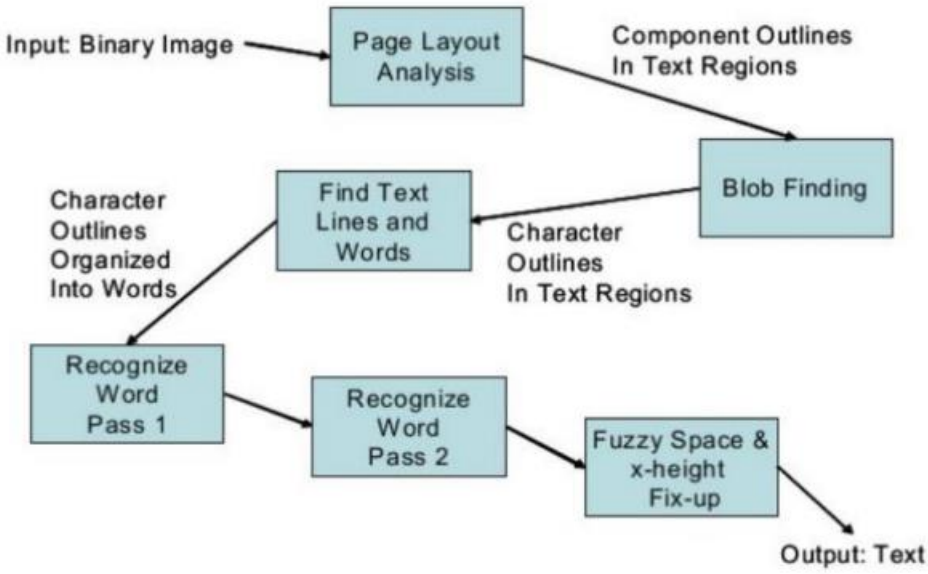

Figure 2:Tesseract's basic component block diagram

Following the page layout review, blobs that are the supposed classifiable unit and overlap Associated bits, internal loop lines, or spaces are located in the text region. Once identified, the line finder distinguishes lines on a line centered on the vertically overlapping neighboring character [46]. Then a detector searches for the fixed pitch structure and performs word segmentation protocols according to the firm's convincing judgment.

The Tesseract word identification block diagram is shown in Figure 3 [45]. Each blob is used by the word recognizer to do a dictionary search to identify a word from the groups of alternatives for classifying each blob. If the output is negative, the unknown characters are deleted, which increases the classifier's confidence. After all cutting choices have been exhausted, a stronger scan of the resultant segmentation diagram reassembles clipped segments or sections that were divided into many CCs. Each level is separated into new blob combinations, and the classifier's findings are returned to the dictionary.

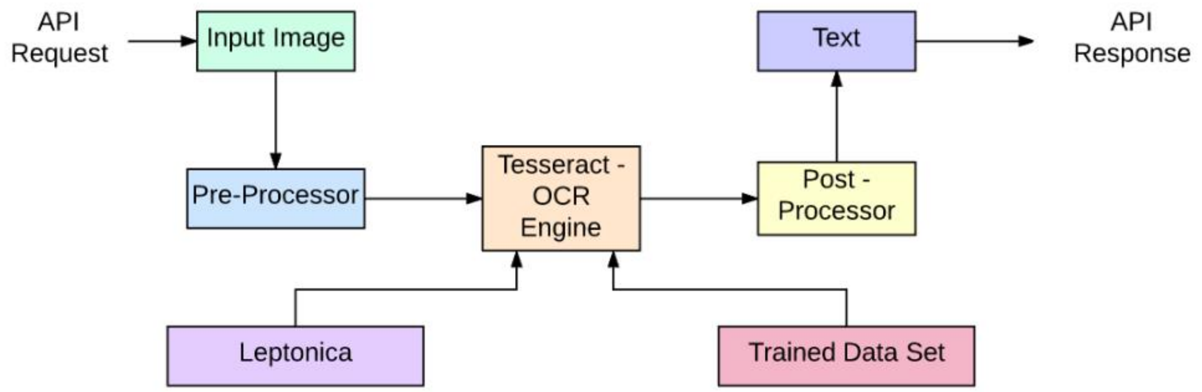

Figure 3:Tesseract OCR Engine Process

However, the vast majority of OCR technology is designed for the English language and may not work as effectively for other languages [6]. The challenges of designing an OCR programme for languages with complicated character sets, such as Sinhala, are significantly greater. Despite these obstacles, the need for inclusive technology for all people continues, and we are committed to building an OCR app that will aid visually impaired Sinhala speakers.

The OCR app we have developed for the Sinhala language is based on a machine learning algorithm that has been trained to recognize Sinhala characters. Our OCR app is designed to provide a reliable and accurate means of recognizing text from digital images, making it easier for visually impaired individuals to access printed materials [7]. In this report, we will present an overview of the development process for our OCR software, including the obstacles we encountered and the solutions we adopted. In addition, we will examine the OCR app's potential use cases and their influence on the lives of visually impaired individuals in the Sinhala-speaking community. Access to information is a fundamental necessity in today's world, as it plays a crucial role in personal growth, education, and career development. Unfortunately, access to printed documents has been a substantial barrier for people with visual impairments. OCR technology offers a solution by converting printed materials into digital text that can subsequently be accessible via assistive devices such as text-to-speech readers.

Nonetheless, there is a notable gap when it comes to OCR technology's applicability to languages other than English .The development of an OCR programe becomes considerably more difficult for languages with complex character sets, such as Sinhala. Regardless of these obstacles, the need for inclusive technology remains critical. This dedication drives the creation of OCR programs for languages such as Sinhala, with the ultimate objective of aiding visually challenged people who speak these languages [6].

Our Sinhala OCR app is built upon a machine learning algorithm trained specifically to recognize Sinhala characters. It is designed to offer reliable and accurate text recognition from digital images, thereby simplifying the process for visually impaired individuals to access printed materials. In this report, we provide insights into the development process of our OCR app, highlighting the challenges we encountered and the solutions we devised [13]. Furthermore, we explore the potential applications of the OCR app and how it can positively impact the lives of visually impaired individuals in the Sinhala-speaking community

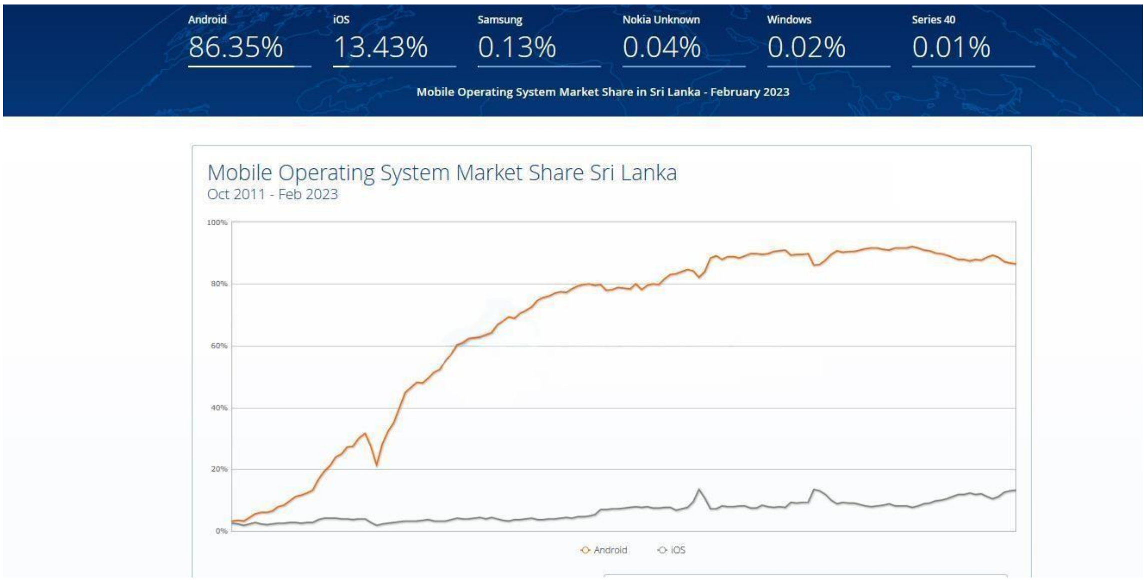

Figure 4:Mobile Operating System Market Share Sri Lanka

Developing a mobile-based Sinhala book reader app for visually impaired individuals can greatly enhance their reading experience and accessibility to literature. The app can use OCR technology to convert scanned images of Sinhala books into editable and searchable text, which can then be read out loud using a text-to-speech (TTS) engine.

To develop such an app, the following steps can be taken:

- Gather requirements: Conduct research to identify the requirements of visually impaired individuals and their needs when it comes to reading Sinhala literature. This can include the ability to adjust font size, background color, and reading speed, among others.

- Design user interface: Design a user-friendly interface that is accessible and easy to navigate for visually impaired individuals. The interface should include options to adjust font size, background color, and reading speed, among others.

- Develop OCR engine: Develop an OCR engine specifically designed for Sinhala script that can accurately recognize characters and convert scanned images into editable and searchable text.

- Integrate TTS engine: Integrate a TTS engine that can read out the converted text aloud, providing an immersive and convenient reading experience for visually impaired individuals.

- Test and optimize: Test the app with visually impaired individuals and gather feedback to identify areas for improvement. Optimize the app to provide a seamless and accessible reading experience.

- Publish the app: Publish the app on the Google Play Store, making it accessible to a wide audience of visually impaired individuals.

Overall, a mobile-based Sinhala book reader app for visually impaired individuals can greatly enhance their accessibility to literature and provide a convenient and immersive reading experience

2.3 Similar Existing Project

Normal Optical Character Recognition for Sinhala Language

Optical Character Recognition (OCR) programs are used to read scanned images and convert them into a digital character-based format. OCR is an important and practical technology in the computer age. On desktops, laptops, tablets, smartphones, and e-readers, more people than ever before are reading books and papers. This implies that paper-based communication materials must be scanned and converted to a digital version in order to be accessed via these devices. Sinhala documents are digitized using Sinhala Optical Character Recognition (SOCR) methods. The SOCR algorithm receives as input a page of scanned text. This comprises typewritten documents and digitized content from newspapers and other sources. As a result, there will be a range of Sinhala character fonts, sizes, and formatting options, including bold and italic.

Common languages like English and French have optical character recognition technologies that are well established and often used. Though there has been very little study on optical character recognition for the Sinhala language, the lack of a reliable OCR engine is a significant issue. It is very necessary for the nation to archive and index historic Sinhala typed materials in electronic format. This will make it possible to search through ancient documents, including newspapers and medical records, to find information that will help with social science research and numerous employment in the public and private sectors.

Three crucial steps must be completed by this application before it can do the character recognition. The first is segmentation, which involves identifying the individual glyphs (basic units that constitute one or more characters, typically contiguous) from a binary input image. A vector of numbers must be calculated from each glyph in the second phase, known as feature extraction, in order to be used as input features by an Artificial Neural Network (ANN). The last task is categorization, which is carried out with the help of ANN.

There is no one perfect approach to acquire these qualities, making this the hardest step. Although the aforementioned description is a general implementation of such algorithms, the intricate character features of Sinhala make the standard core mechanics of these algorithms insufficient. In this case, a novel approach is required. This work suggests a character identification method that is rotationally invariant and mirrors the human brain. Since this method is more functionally similar to human perception, it has been demonstrated to be effective. The study also suggests a novel method for building Artificial Intelligence (AI) systems that takes a more natural approach rather than complex algorithms that use more power. With new technology, it is now possible to implement such algorithms in embedded systems to generate low-cost systems.

Sinhala Optical Character Recognition (Socr) Algorithm

The method used to create this original AI algorithm was different from the conventional method used to create AI systems. This is further emphasized by the created algorithm's block design .

The main steps of data training used in this project :-

A. Pre Processing

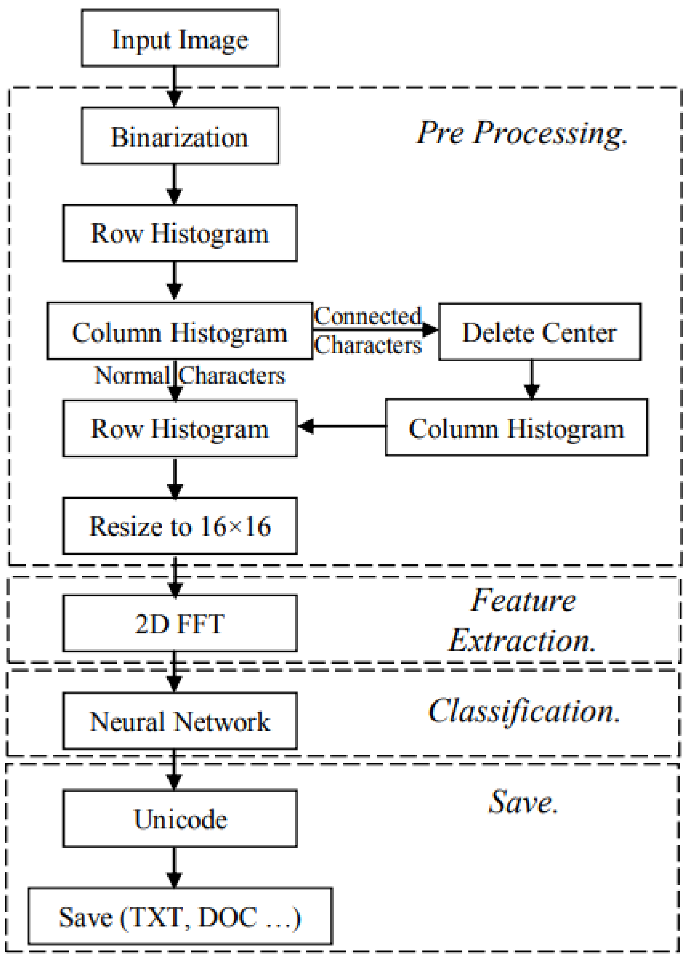

Figure 5:OCR Algorithm Block Diagram.

B. Feature Extraction

One of the key areas is feature extraction since good features increase recognition rates and reduce error when there is noise, whereas bad features produce subpar results. Finding a set of features that maximizes recognition rate while using the fewest number of components is the main objective of feature extraction. To satisfy the above facts in this project 2D Fast Fourier Transform (2DFFT) was chosen as the feature vector [4]. Fourier Descriptors are utilized in calculating the Discrete Fourier coefficients (DFT) a[k] and b[k] for $0 \leq k \leq (L - 1)$,

a k =1 (L x[m]e-jk(2π/L)m) (1)

b k = 1 (L y[m]e-jk(2π/L)m) (2)

The absolute values of the Furrier transform have the invariant property with regard to rotation and shift, however the Fourier coefficients produced from Equations 1 and 2 are not rotational or shift invariant. So, as shown below, invariant descriptors r(n) were computed.

r n =[|a(n)|2 +|b(n)|2] ½

A DC component, which naturally has a bigger magnitude than other frequency components, makes up the initial component of r(n). This DC component gives the neural network input a wider dynamic range by causing other input values to become negligibly small while normalizing values for the neural network. Therefore, a new descriptor s(n) is computed using the logarithmic value of r(n) in order to prevent the prominence of this DC component.

s n =log(r(n))

Now s(n) becomes the input to the neural network.

C. Neural Network.

Numerous approaches are used to deal with character recognition, however the most effective ones incorporate AI concepts. As a result, Sinhala characters were classified and identified using a neural network. There should be around 600 distinct shapes that Sinhala speakers may identify. This algorithm used a unique neural network as a result. The neural network of this algorithm is divided into two parts. For the input character, one set of neural networks will decide on the proper class. The input character is then recognised by another neural network in that class. To begin, a straightforward Multi layer perceptron (MLP) neural network was built to identify six characters belonging to a particular class.

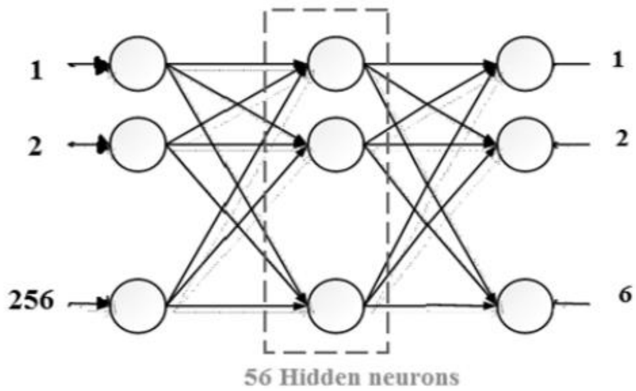

Figure 6:Basic Network Topography.

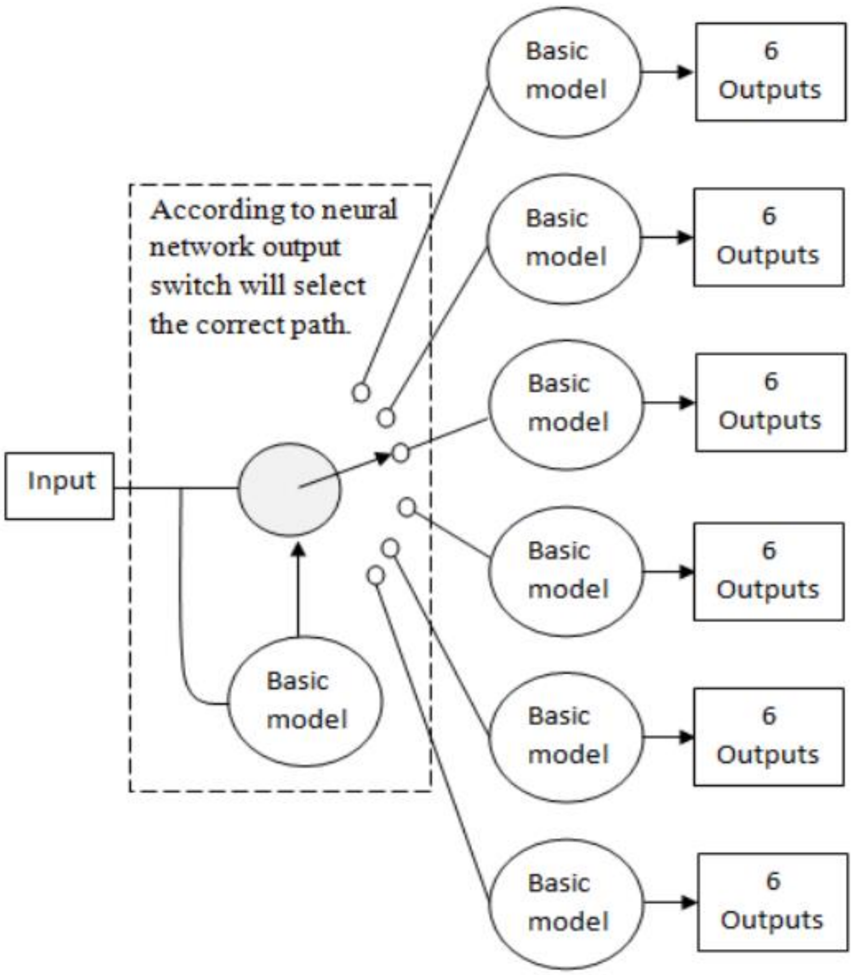

Figure 7:Main Network Topography

To detect as many characters as is practical, the neural network's structure and dynamics were enhanced. The character at the input was initially assigned to a certain class using the front-end neural network. In order to process input between characters of a given class, the first neural network functions as a multiplexer, choosing the right class. In its initial categorization, the front-end neural network uses the attributes with the greatest discrepancies. We may evaluate the effectiveness of this neural network implementation by examining the character classes.

Figure 8:Classifications of Characters

D. Saving

This stage involves typing detected characters into a text file in Sinhala. The output of the sub neural network that employs 1-of-C coding and the sub neural network itself reveal the classification path that was taken to classify the input character, allowing the proper Unicode character to be written to the text file. A bounding box for the segmented area was used to check the segmentation findings. In order to check, scanned images in Tamil and Sinhala were both used, and the findings were displayed.

Description	No. of correctly segmented characters	No. of incorrectly segmented characters	Percentage of correctly segmented characters
Sinhala NEWS paper	52	8	86.67%
Tamil book	56	4	93.33%
Sinhala FMAbhya (font size 12)	42	8	80.95%
Sinhala FM malithi (font size 12)	42	13	70.04%
Sinhala 4u-Emanee (font size 24)	42	10	80.76%
Sinhala 4u-Emanee (font size 18)	53	10	81.13%

Figure 9:Experimental Results Of Segmentation

2.4 Research gap

One of the most pronounced research gaps in the OCR component is the pressing need for a dedicated and highly accurate OCR engine designed specifically for the Sinhala language. While advanced OCR programmes exist for frequently used languages such as English and a few other generally spoken languages, there is a major lack of OCR tools designed specifically for Sinhala and other less commonly used languages. As a result, building an OCR engine capable of properly recognizing and classifying Sinhala characters and fonts of varied sizes constitutes a significant development in assistive technology for visually impaired people in Sri Lanka and other Sinhala-speaking groups. This gap implies a critical necessity for the creation of an OCR engine that can seamlessly adapt to the intricacies and nuances of the Sinhala script, thus contributing significantly to improving accessibility for those with visual impairments.

Another notable research gap in the field of Sinhala OCR technology pertains to the integration of machine learning techniques to enhance the accuracy and efficiency of the OCR engine. Machine learning approaches have shown promise in training OCR systems to recognize and classify various types of Sinhala text. The OCR engine can be trained to attain higher levels of accuracy and speed by using huge and different datasets of Sinhala characters and fonts, resulting in a more dependable and efficient tool for visually impaired users. This research gap highlights the necessity of leveraging machine learning to increase the capabilities of Sinhala OCR technology.

One possible research gap in the OCR component is the need for a more accurate and efficient OCR engine specifically designed for the Sinhala language. While there are existing OCR programs for English [10] and other widely used languages [5], there is a lack of OCR tools available for Sinhala and other less commonly used languages. Thus, developing an OCR engine that can accurately recognize and classify Sinhala characters and fonts of various sizes would be a significant contribution to assistive technology for visually impaired individuals in Sri Lanka and other Sinhala-speaking communities. Another possible research gap is the need to incorporate machine learning techniques to improve the accuracy and speed of the OCR engine. By using a large dataset of Sinhala characters and fonts, the OCR engine can be trained to better recognize and classify different variations of Sinhala text, resulting in a more reliable and efficient tool for visually impaired individuals.

When a certain Sinhala book is photographed with a camera and sent to the TTS, the OCR will identify it . Only a few studies in Sri Lanka have been done to create a synthetic Sinhala voice.

Most character recognition systems use a scanner and a monitor to capture input images. The system and scanner are a concern because they take up less room. The issue of the computer and scanner taking up too much space was addressed by an optical character recognition system (OCR) built on an Android 14 phone. 14 Digital camera images differ from scanned documents or photos in several ways. In addition, they contain flaws such as edge distortion and bad illumination, which inhibits the majority of OCR solutions from successfully identifying the text. The Tesseract OCR engine was selected for the study due to its extensive acceptability, extensibility, and accessibility, as well as its engagement in building culture and its ability to function as intended[18] .

One major gap is the lack of high-quality datasets for training OCR models for Sinhala characters. While there are some publicly available datasets, they are often limited in size and scope. To improve the accuracy of OCR technology for Sinhala, larger and more diverse datasets are needed. Another challenge is the complexity of Sinhala script, which includes a wide range of ligatures and diacritics that can make character recognition more difficult. Further research is needed to develop OCR algorithms that can accurately identify and recognize these complex character forms. There is also a need to develop better methods for word formation in Sinhala. This is particularly important for handwritten text, which can often contain variations in spelling and word structure. Improved word formation methods could help improve the accuracy of OCR technology for Sinhala. Finally, while machine translation technology has improved significantly in recent years, there is still a need for further research on translating Sinhala text into other languages. This is particularly important for languages with limited linguistic resources, where the quality of machine translation can be a significant barrier to cross-linguistic communication.

OCR technology has the ability to significantly increase access to Sinhala literature and promote interlanguage communication, but there is still more to be done to increase its efficacy and accuracy for the recognition of Sinhala characters and word formation.

Sinhala character identification, word generation using an engine, voice translation, and transmission to TTS are all steps in the process. Users can read the time using a background process even when the app is not open. When a user starts the software using voice instructions, the camera should also be able to start. When the user runs the program, it needs to be able to scan the document rapidly. The software must be able to focus automatically on the piece of paper in front of the camera. The system should notify the user vocally as soon as the document enters the capture frame. whenever the document is entirely within the capture frame, capture it and get the image. The acquired image should be kept in the device's storage. The OCR system must first identify and rectify skew before receiving data.

In summary, the field of Sinhala OCR technology presents several notable research gaps that need to be addressed to achieve higher accuracy and effectiveness. These gaps encompass the development of a specialized Sinhala OCR engine, the incorporation of machine learning techniques, the availability of high-quality datasets, the complexity of the Sinhala script and word formation, and the challenges of cross-linguistic translation. Closing these gaps represents a significant stride towards advancing accessibility and inclusivity for visually impaired individuals in Sinhala-speaking communities.

Table 3:Table of research papers

Application Reference	OCR system for identifying the included texts of a image which supports for visually impaired people	Support for Sinhala Language	Until the document is within the capture frame, the system should alert the user audibly.	Uses for multi-font and multi size fonts identification,supported by segmenting the characters	Mobile Application
Research A	⊗	⊗	⊗	✓	⊗
Research B	⊗	⊗	⊗	⊗	⊗
Research C	✓	⊗	⊗	✓	⊗
Research D	✓	⊗	⊗	✓	✓
Proposed System	✓	✓	✓	✓	✓

2.5 Research problem

The main research problem is that most visually impaired people in Sri Lanka do not have access to a platform that enables them to capture the text they need and read it. To address this problem, it is important to first understand the limitations that visually impaired people face when using smartphones. One major limitation is the lack of accessibility features that cater to their needs. For example, many smartphones do not have built-in screen readers or other assistive technologies that make it easier for visually impaired individuals to use the device.

Additionally, some visually impaired individuals may have limited knowledge about how to use these technologies and may require additional training and support to take full advantage of them. Another limitation that visually impaired individuals face is the quality of digital images captured by smartphone cameras. In order for OCR technology to work effectively, the text needs to be captured in high resolution and with proper lighting. Many smartphones do not have cameras that are suitable for capturing high-quality images, which can make it difficult for visually impaired individuals to use OCR apps to capture and read text.

By exploring these limitations and identifying potential solutions, it may be possible to develop a platform that meets the needs of visually impaired individuals in Sri Lanka, enabling them to capture and read the text they need using their smartphones. This could have a significant impact on the quality of life of visually impaired individuals by providing them with greater access to information and opportunities for personal growth and development.

Another problem I have identified is related to the development of an Optical Character Recognition (OCR) system that can accurately identify Sinhala characters and form words using an engine, and then translate the text to speech. This is a challenging problem because Sinhala is a complex language with a unique set of characters that require specialized algorithms for recognition and word formation.

Some of the specific research questions that could be addressed in this project include:

1. What are the most effective algorithms for accurately identifying Sinhala characters using OCR technology?
2. How can these algorithms be optimized for different fonts, styles, and sizes of Sinhala text?
3. What are the best techniques for combining identified characters into words using an engine?
4. How can the system be trained to recognize Sinhala words in different contexts and accurately translate them to speech?

5. What are the most effective approaches for integrating the OCR, word formation, and text-to-speech technologies into a cohesive system?

To address these research questions, the project would likely involve a combination of machine learning, natural language processing, and computer vision techniques. It would also require a large dataset of Sinhala text and audio recordings for training and testing the system. The end result would be a valuable tool for people who are visually impaired or have difficulty reading Sinhala text.

- Sinhala OCR for General Use: Several OCR systems have been developed for the Sinhala language, primarily focusing on converting printed or handwritten Sinhala text into digital format. These OCR systems are designed to serve a broad audience, including researchers, businesses, and government agencies. Examples include OCR software like "Sinhala OCR" and "Sinhala Optical Character Recognition" (SOCR), which are aimed at general text recognition purposes.

- Commercial OCR Solutions: Commercial OCR solutions that support Sinhala text recognition have also been available. These solutions are typically versatile and can recognize multiple languages, including Sinhala. They are used for various applications, such as document scanning, data extraction, and text conversion.

- Sinhala OCR for Document Digitization: Some projects have focused on using OCR to digitize historical or cultural documents written in Sinhala. These projects aim to preserve and make accessible valuable historical and literary resources.

Table 4:Existing Research Questions and Motivation.

Research question	Motivation
What different feature extraction and classifications methods are used for handwritten OCR?	To identify trends in used feature extractors and machine learning techniques over almost two decades.
What different datasets/databases are available for research purpose?	Availability of a dataset with enough data is always a fundamental requirement for building OCR system [55].
What major languages are investigated?	To highlight which languages have usually been investigated. Thus identifying languages which need more research attention.
What are the new research domains in the area of OCR?	To provide guidance for new research projects.

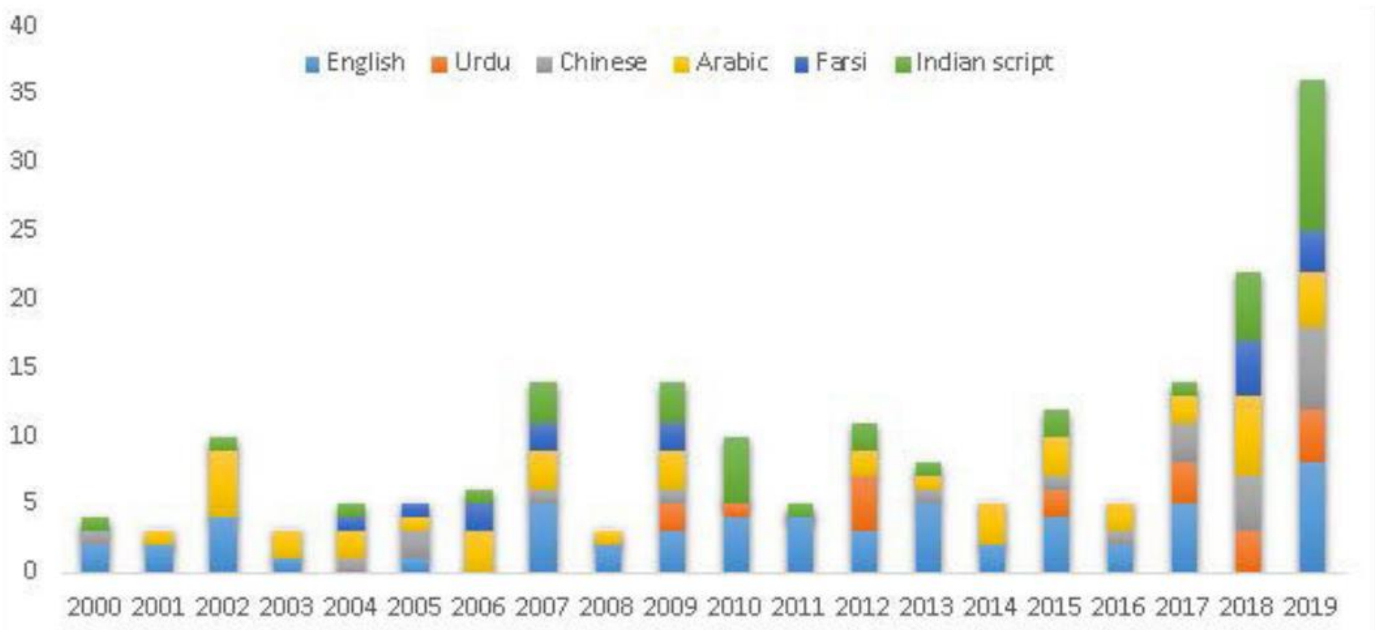

Figure 10:Selected studies count each year with respect to specific language.

- y-axis shows the number of selected studies. Specific color within each bar represents specific language as shown in the legend.

Comparison with Sinhala OCR for Blind Children:

A Sinhala OCR system specifically designed for blind children would have distinct features and considerations compared to general-purpose Sinhala OCR systems:

- Accessibility Features: The Sinhala OCR for blind children would prioritize accessibility features, such as seamless integration with screen readers, Braille output, and user-friendly interfaces tailored to the needs and capabilities of young users.

- Customized Learning Tools: To support the educational needs of blind children, the OCR system might incorporate features for interactive learning, such as pronunciation assistance, vocabulary building, and reading comprehension exercises.

- Textbooks and Educational Materials: Special attention would be given to recognizing Sinhala text from educational materials, including textbooks, workbooks, and classroom handouts. The system might also support mathematical notation recognition for subjects like mathematics and science.

- Voice Guidance: A Sinhala OCR for blind children might provide voice guidance and audio prompts to assist them in capturing images and using the system independently.

- Language Variation Handling: The system should be sensitive to variations in Sinhala script and pronunciation, taking into account the simplified Sinhala Braille script used by blind individuals.

- Learning and Growth: The OCR system for blind children could incorporate features to adapt and grow with the users as they progress in their reading and learning abilities.

- Educational Content Repository: It might include an educational content repository with a collection of accessible Sinhala language books and materials suitable for children.

2.6 Research findings & discussion

In the research findings and discussion section of the study focusing on the Sinhala book reader for visually impaired individuals with OCR, several noteworthy findings emerged. The accuracy of OCR recognition, particularly for intricate Sinhala characters and diverse fonts, was a pivotal aspect, with recognition rates varying based on character complexity and source material quality. The effectiveness of the text-to-speech synthesis (TTS) system, evaluated for its ability to provide natural and intelligible speech, greatly influenced user experience. User feedback revealed valuable insights into the software's usability, navigation, and overall user satisfaction. Furthermore, the study unveiled the transformative impact of the application on the lives of visually impaired individuals, facilitating heightened access to literature, expanded educational horizons, and enriched cultural engagement within the Sinhala-speaking community.

In addition to these findings, the research uncovered persistent challenges, including issues related to dataset availability and achieving optimal recognition accuracy for specific Sinhala scripts. Ethical considerations regarding privacy, data security, and copyright compliance were thoughtfully addressed in the discussion.
These challenges and ethical dilemmas have laid the foundation for promising future directions in OCR technology and the development of more inclusive accessibility solutions for the visually impaired.

The active involvement and unwavering support of the community, comprising visually impaired individuals, educators, and dedicated volunteers, proved instrumental in shaping the project's success. Their contributions enriched the project and reflected the collaborative spirit of inclusive technology development. Overall, the study underscored the profound significance of the Sinhala book reader in elevating the quality of life and educational prospects for visually impaired individuals. Simultaneously, it contribute meaningfully to the broader discourse on the transformative potential of inclusive technology, particularly in empowering marginalized communities and promoting equitable access to knowledge and culture.

Research Findings & Discussion for Sinhala Book Reader for Visually Impaired Individuals with OCR:

1. Accuracy of OCR Recognition:

- Findings: The OCR system's recognition accuracy for Sinhala characters and fonts was a critical aspect of the research. The accuracy rates varied depending on the complexity of the characters and the quality of the source material.
- Discussion: Discuss the OCR model's performance and highlight any challenges faced in achieving high accuracy. Address any specific issues related to Sinhala characters, such as ligatures and variations in fonts.

2. Effectiveness of Speech Synthesis (TTS):

- Findings: The text-to-speech (TTS) synthesis was a key component in making Sinhala literature accessible to visually impaired individuals. The quality and naturalness of the synthesized speech were evaluated.
- Discussion: Discuss the impact of TTS quality on user experience. Highlight any user feedback regarding speech clarity and expressiveness. Address any improvements made to enhance TTS effectiveness.

3. User Feedback and Usability:

- Findings: Visually impaired individuals actively participated in testing the Sinhala book reader. Their feedback on usability, navigation, and overall experience was collected.
- Discussion: Analyze user feedback and describe how it influenced improvements in the application's user interface and functionality. Discuss any challenges identified during user testing and the corresponding solutions implemented.

4. Impact on Visually Impaired Individuals:

- Findings: The research assessed the impact of the Sinhala book reader with OCR on the lives of visually impaired individuals. This included its role in enhancing access to literature, education, and cultural engagement.
- Discussion: Discuss the positive outcomes observed among visually impaired users, such as increased reading

5. Opportunities and educational benefits. Explore how the application contributed to personal growth and improved quality of life within the Sinhala-speaking community.

6. Challenges and Future Directions:

- Findings: Identify any persistent challenges or limitations encountered during the research, such as dataset availability, recognition accuracy for specific Sinhala scripts, or device compatibility issues.
- Discussion: Discuss potential avenues for future research and development, including strategies to address existing challenges. Consider opportunities to expand the application's features and accessibility to reach a broader audience.

7. Ethical Considerations:

- Findings: Ethical considerations, including privacy, data security, and copyright, should be addressed, especially when dealing with user-generated content or copyrighted materials.
- Discussion: Reflect on the ethical aspects of the research and how they were managed to ensure responsible use of technology and compliance with legal and ethical standards.

8. Community Involvement and Support:

- Findings: The research likely involved collaboration with visually impaired individuals, educators, and the broader community.
- Discussion: Highlight the importance of community engagement and support in the development of the Sinhala book reader. Discuss how feedback and contributions from the community enriched the project.

9. Conclusion and Contributions:

- Findings: Summarize the main findings of the research, emphasizing the achievements and contributions of the Sinhala book reader with OCR.
- Discussion: Conclude by highlighting the significance of the project in promoting accessibility, literacy, and cultural engagement among visually impaired individuals in the Sinhala-speaking community. Discuss the broader implications and potential for future advancements in inclusive technology.

2.7 Project requirements

2.7.1 Functional requirements

1. OCR System: The OCR system should be able to accurately recognize and convert Sinhala text from printed materials into digital text that can be read by the app.

2. Offline Support: The app should be able to function offline so that users can read books and use the app without an internet connection.

3. Feedback and Support: The app should provide users with a way to provide feedback and receive support from the developer if they encounter any issues or have suggestions for improving the app.

4. Book Import: The app should allow users to import digital books in Sinhala language from external sources such as the internet or other mobile devices.

The functional requirements of the developed Sinhala book reader for visually impaired individuals with OCR encompass a comprehensive set of features and capabilities aimed at providing an inclusive, user-friendly, and enriching reading experience. First and foremost, the application should offer accurate and efficient Optical Character Recognition (OCR) functionality, capable of recognizing a wide range of Sinhala characters and fonts from scanned or photographed text. Users should be able to capture text from physical books or documents using their smartphone cameras, with the OCR engine converting this text into machine-readable form.

The application should seamlessly integrate a Text-to-Speech (TTS) synthesis system, offering high-quality and natural-sounding voice output in the Sinhala language. Users should have the flexibility to adjust the TTS settings to suit their preferences, such as speech rate, pitch, and volume. Additionally, the TTS system should support the reading of Sinhala literature with appropriate pronunciation and intonation.

Navigation and usability are paramount, with the application featuring an intuitive and accessible user interface optimized for visually impaired users. This includes features like gesture-based controls, audio feedback, and screen reader compatibility. Users should be able to easily browse, search, and select books from a vast library of Sinhala literature. The application should also offer the ability to download books for offline reading, ensuring access even in areas with limited internet connectivity.

To cater to a diverse audience, the application should provide customization options, allowing users to adjust text size, font styles, and background colors for comfortable reading. It should also support braille displays and keyboard shortcuts for those who prefer alternative input methods.

Furthermore, the application should offer educational tools, such as text highlighting synchronized with audio narration, to aid visually impaired students in their studies. It should track reading progress, provide reading comprehension exercises, and offer access to dictionaries .

Community features are essential, with the application fostering a sense of belonging among visually impaired users. This includes support forums, book clubs, and user-generated content sharing, allowing individuals to connect, exchange recommendations, and share their experiences.

Accessibility remains a top priority, with the application adhering to international accessibility standards and ensuring compatibility with screen readers, voice assistants, and other assistive technologies. Moreover, the app should be adaptable to various mobile devices and operating systems to reach a broader audience.

Finally, continuous improvement and support are fundamental requirements. The development team should actively seek user feedback, address technical issues promptly, and regularly update the application to incorporate new Sinhala literature, improve OCR accuracy, and enhance overall performance. In essence, the Sinhala book reader for visually impaired individuals with OCR should not only break down barriers to reading but also empower users with the tools and resources needed to engage with Sinhala literature and culture inclusively and effectively.

2.7.2 Non-Functional requirements

1. Usability:
    - The app should be easy to use and navigate, with intuitive controls and a simple user interface.
2. Accessibility:
    - The app should be designed with accessibility in mind, with features such as large buttons, high contrast mode, and adjustable text size to make it accessible for visually impaired users.
3. Performance:
    - The app should be fast and responsive, with minimal lag time between actions such as turning pages or adjusting text settings.
4. Reliability:
    - The app should be stable and reliable, with minimal crashes or errors during use.
5. Security:
    - The app should be secure and protect user data, with features such as encryption of sensitive information and secure storage of user data.
6. Compatibility:
    - The app should be compatible with a wide range of Android devices, including older and newer devices with varying screen sizes and hardware specifications.
7. Maintainability:
    - The app should be designed with maintainability in mind, with clear code organization and documentation to make it easier for developers to maintain and update the app over time.
8. Performance under low network conditions:
    - The app should be able to function with slow internet or low network connectivity, as users may not always have access to high-speed internet.

9. Multilingual OCR Support:
    - The OCR system should support multiple languages, including Sinhala, to enable the recognition and conversion of text from books written in different languages.

10. Accuracy of OCR:
    - The OCR system should be accurate in recognizing and converting printed Sinhala text, to ensure the digital text output is of high quality and readable by the app.

The non-functional requirements of the developed Sinhala book reader for visually impaired individuals with OCR encompass critical aspects that define the application's overall quality, performance, and user experience. First and foremost, the application should prioritize Accessibility as a non-negotiable requirement. It must conform to international accessibility standards such as WCAG (Web Content Accessibility Guidelines) to ensure that visually impaired users can seamlessly navigate, interact with, and derive value from the application. This includes compatibility with screen readers, keyboard shortcuts, and voice command recognition, ensuring that the app is universally accessible to all individuals with visual impairments.

Reliability and Stability are paramount, with the application expected to function consistently and without glitches. Visually impaired users rely heavily on the application for their reading needs, and any system failures or crashes would severely impact their experience. The app must undergo rigorous testing to guarantee its stability, particularly when handling resource-intensive tasks such as OCR processing and TTS synthesis.

Performance Efficiency is another key non-functional requirement. The application should be optimized to perform efficiently on a range of devices, from low-end smartphones to high-end tablets, without compromising functionality or responsiveness. Additionally, it should be mindful of limited data connectivity in certain regions, ensuring that users can access their books and utilize OCR capabilities even in areas with slow or intermittent internet access.

Security and Privacy are non-negotiable requirements, especially when dealing with user-generated content and personal data. The application should implement robust security measures to protect user information, prevent unauthorized access, and safeguard against data breaches. Moreover, privacy concerns should be addressed by giving users control over their data and obtaining explicit consent for any data collection or sharing activities.

Scalability is essential to accommodate a growing user base and expanding content library. The application should be designed with scalability in mind, capable of handling increased traffic and growing demands without compromising performance or user experience. Interoperability is crucial as the application should seamlessly integrate with various assistive technologies, operating systems, and screen readers commonly used by visually impaired individuals. Compatibility with a wide range of devices and platforms ensures that the app is accessible to the broadest audience possible.

Maintainability and Continuous Improvement are ongoing requirements. The development team should commit to regular updates, bug fixes, and enhancements to keep the application current and responsive to user needs. This includes expanding the content library, improving OCR accuracy, and incorporating user feedback for iterative development.

Lastly, User Support and Documentation are essential non-functional requirements. The application should provide comprehensive user documentation and responsive customer support channels to assist users with technical issues, questions, or concerns. This ensures that visually impaired individuals can navigate and utilize the app effectively, fostering a positive and inclusive user experience.

2.7.3 Software Requirements

The software requirements for the developed Sinhala book reader for visually impaired individuals with OCR encompass a comprehensive set of features and functionalities that collectively enable a user-friendly, inclusive, and enriching reading experience. Firstly, the application should have a robust Optical Character Recognition (OCR) system capable of accurately recognizing a wide range of Sinhala characters and fonts from scanned or photographed text. This OCR component should operate efficiently, ensuring quick text extraction and conversion. Additionally, the application should incorporate a high-quality Text-to-Speech (TTS) synthesis system that seamlessly converts recognized text into natural and intelligible Sinhala speech, allowing users to listen to the content with clarity and comprehension.

User Interface (UI) requirements are vital, with the application featuring an intuitive and accessible UI specifically designed for visually impaired users. It should incorporate gesture-based controls, audio feedback, and compatibility with screen readers, ensuring ease of navigation and interaction. The UI should also facilitate efficient browsing, searching, and selection of books from a diverse library of Sinhala literature.

Customization options are essential, allowing users to personalize their reading experience. This includes settings to adjust text size, font styles, background colors, and TTS voice preferences, ensuring comfort and adaptability to individual needs. Moreover, the application should support braille displays and keyboard shortcuts for those who prefer alternative input methods.

Offline access is a crucial requirement, enabling users to download books for reading without an internet connection, thus ensuring access in areas with limited connectivity. Educational tools should also be integrated, including synchronized text highlighting with audio narration to aid visually impaired students in their studies. The application should track reading progress, offer reading comprehension exercises, and provide access to dictionary and translation services to enrich the learning experience.

Community features should foster a sense of community among visually impaired users, including support forums, book clubs, and user-generated content sharing. These features promote social engagement, information exchange, and a sense of belonging within the user community.

Accessibility remains a top priority, with the application adhering to international accessibility standards and ensuring compatibility with screen readers, voice assistants, and other assistive technologies. Additionally, the app should be adaptable to various mobile devices and operating systems, reaching a wider audience.

Continuous improvement and support are ongoing requirements, with the development team actively seeking user feedback, addressing technical issues promptly, and regularly updating the application to incorporate new Sinhala literature, enhance OCR accuracy, and improve overall performance.

In conclusion, the software requirements encompass OCR and TTS capabilities, an intuitive and accessible user interface, customization options, offline access, educational tools, community features, accessibility compliance, adaptability to diverse devices, and a commitment to continuous improvement. These requirements collectively ensure that the Sinhala book reader for visually impaired individuals with OCR delivers a comprehensive and empowering reading experience for its users.

2.7.4 Personal Requirements

The personal requirements for visually impaired individuals using the developed Sinhala book reader with OCR are centered on tailoring the application to their specific needs and preferences, fostering an inclusive and empowering reading experience. Firstly, users should have the ability to customize the user interface and settings to suit their individual preferences. This includes options to adjust text size, font styles, background colors, and TTS voice characteristics, allowing users to create a reading environment that is comfortable and tailored to their unique needs.

Navigation and interaction should be intuitive and adaptable to various accessibility tools and input methods. Visually impaired users may rely on gestures, braille displays, keyboard shortcuts, or voice commands, and the application should seamlessly accommodate these preferences, ensuring that users can effortlessly navigate and interact with the content.

Users should have access to a diverse and expansive library of Sinhala literature that caters to different interests and reading levels. The application should offer personalized book recommendations based on individual reading history and preferences, allowing users to discover new content that aligns with their interests.

Moreover, the Sinhala book reader should prioritize offline access, recognizing that not all users have constant internet connectivity. Users should be able to download books for offline reading, ensuring that the joy of reading is always within reach, regardless of their location or connectivity status.

Education-focused features should be incorporated to support visually impaired students in their studies. This includes tools for text highlighting synchronized with audio narration, tracking reading progress, offering reading comprehension exercises, and providing access to dictionaries and translation services to facilitate learning and comprehension.

Community engagement and support are also essential personal requirements. Users should have access to support forums and book clubs where they can connect with peers, seek advice, and share their experiences. The sense of belonging within a community of visually impaired individuals can be highly motivating and enriching.

Finally, the application should ensure data privacy and security, respecting users' personal information and reading preferences. Transparent data handling practices and options for data control and consent are crucial to establishing trust and comfort among users.

In essence, the personal requirements for visually impaired individuals using the Sinhala book reader with OCR revolve around customization, accessibility, diverse content, offline access, educational support, community engagement, and data privacy. By addressing these requirements, the application creates an environment where visually impaired individuals can access, enjoy, and engage with Sinhala literature on their terms, enhancing their overall quality of life and educational opportunities.

2.8 Summary

Mainly in this chapter, some of the already existing models that have addressed similar issues were compared with our solution and the significance of our work was highlighted. A brief overview about Optical Character Recognition (OCR) technology was also discussed. Also the types of requirements have been gathered . Chapter 3 will discuss the software implementation process.

Chapter 03
METHODOLOGY

3.1 Introduction

This chapter gives an overview of the software implementation process of the design and also provides a detailed discussion about the technologies and tools used.

3.2 Overview of the proposed work

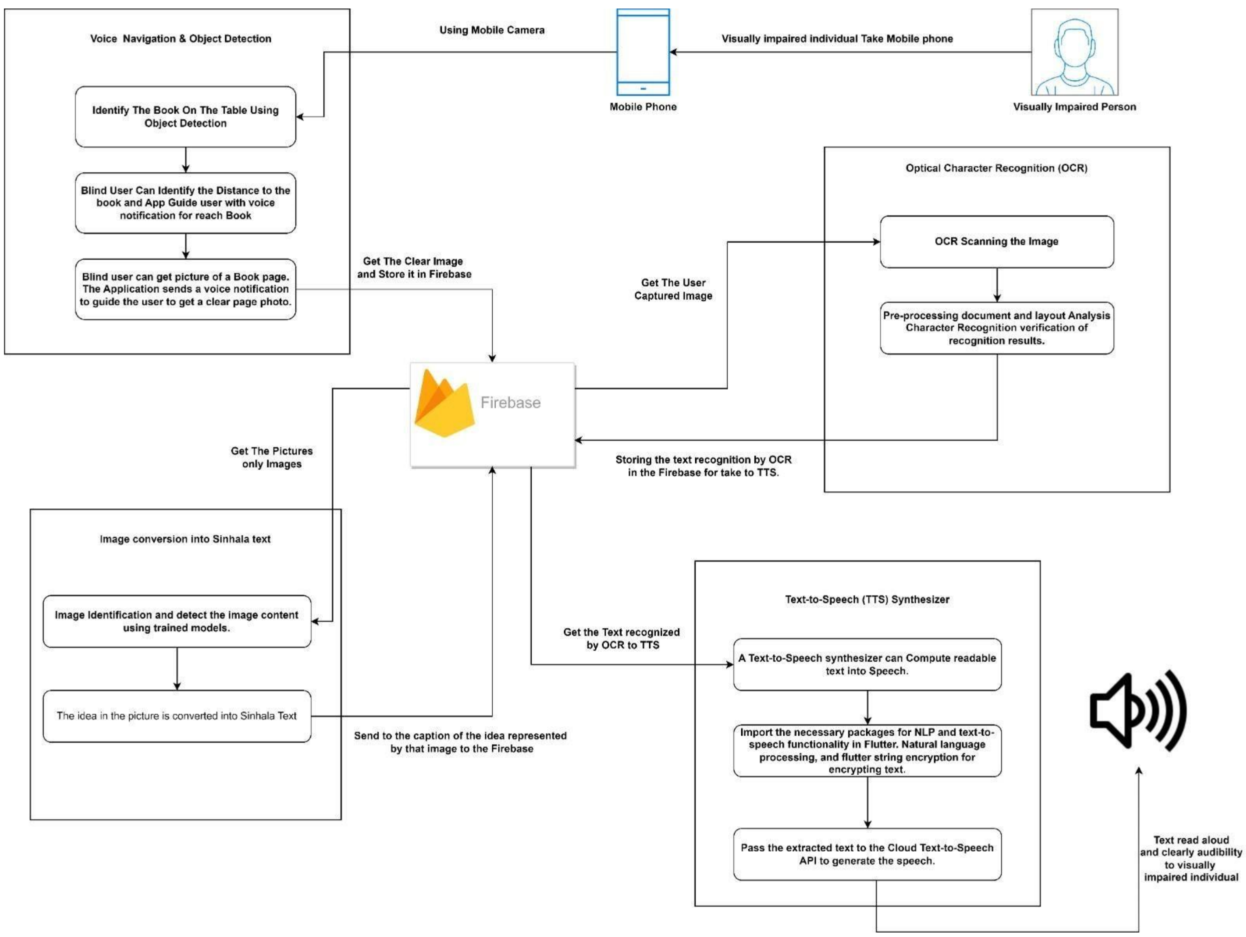

Figure 11:Overall system diagram

When a user is having trouble completing a task, Audible Guidance can be used to guide them through the app's capabilities and provide guidance. When a user opens the camera through the app and aims it towards a table or desk to identify a book, the app recognises the user's hand and directs navigation to the book. Using real-time image processing technology, the user will be verbally warned of any harmful objects around and their distance from them, as well as the likelihood that an accident will occur. Users will move through a clean environment while avoiding hazards and hazardous objects.

Sinhala character recognition, word construction using an engine, voice translation, and transmission to TTS. Users can use a background process to read the time even when the app is not open. When the user begins the programme using voice instructions, the programme ought to be able to launch the camera as well. When the user runs the programme, it should be able to swiftly scan the document. The application must have the ability to focus automatically on the paper in front of the camera. The system should sound an audible warning to the user until the document is within the capture frame .A computer vision system that uses cutting-edge methods to recognize and describe objects and scenes in real-time is an image detection software for blind students. The program takes pictures of the user's surroundings using the camera on a smartphone or tablet. These images are then processed using image-processing techniques including edge detection, colour analysis, and feature extraction to identify the objects and their attributes. Machine learning models are used to identify and categorise the objects in the image once the objects have been located in the image using object detection methods. These models are trained on enormous datasets of annotated photographs and employ techniques like convolutional neural networks (CNNs) to recognise objects in real-time.

Here, the primary goal of adopting Text to Speech (TTS) technology is to enable a blind person to access a Sinhala book's written text. This makes it simple for them to listen to the worthwhile material in Sinhala novels. TTS technology enables a Sinhala book's written text to be read aloud in a natural-sounding voice, making it simpler for those who are blind to comprehend the language. The system analyses the text in Sinhala using computer algorithms to provide the proper pronunciation, intonation, and rhythm for each word and sentence.

3.3 Individual Contribution

3.3.1 OCR methodology and system diagram

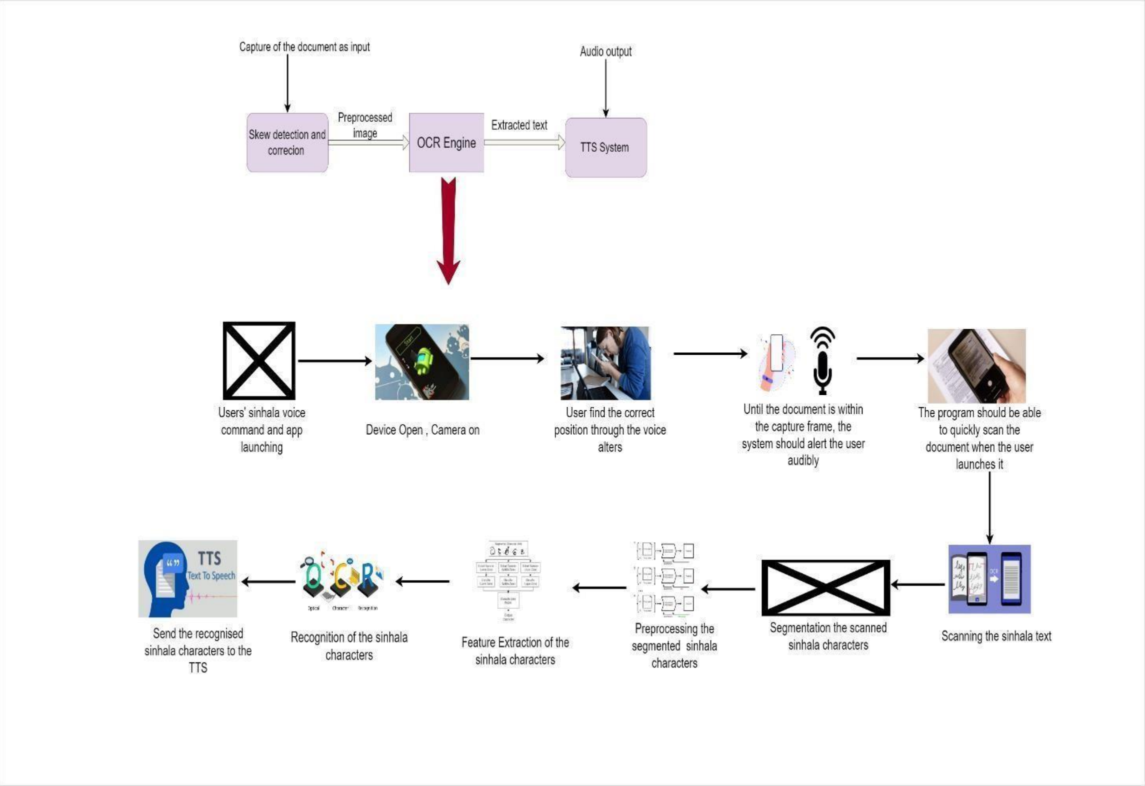

Figure 12:OCR system diagram

Developing a Sinhala OCR (Optical Character Recognition) methodology involves a series of systematic steps: beginning with image acquisition and enhancement to improve image quality, followed by character segmentation to identify individual Sinhala characters within the images. Feature extraction selects critical attributes from the segmented characters, creating feature vectors. Character recognition leverages machine learning algorithms, utilizing a dataset of known Sinhala characters for training, and subsequently assigning character labels based on extracted features. Post-processing steps may include language models and dictionaries to refine recognition results. The output is machine-readable Sinhala text, which can be stored digitally or converted into speech for accessibility. Continuous accuracy evaluation and iterative improvement, often driven by user feedback, refine the OCR system's performance, with the ultimate aim of accurately transcribing printed Sinhala text into a digital format for diverse applications, including assisting visually impaired individuals and facilitating information retrieval.

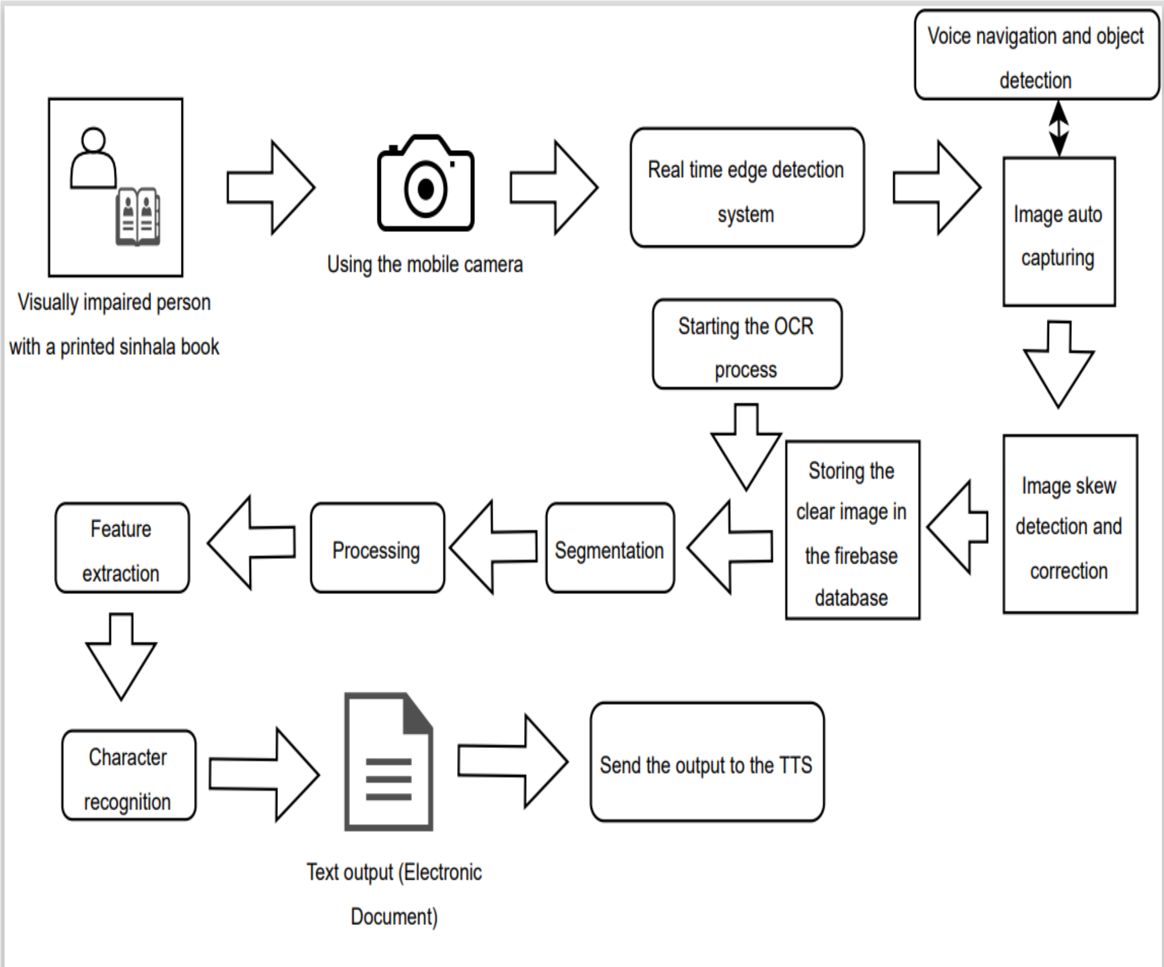

Figure 13:OCR system diagram -structural

3.3.2 Development Process

3.3.2.1 Dataset making and training process

First and the most I have collected different type of Sinhala images and made a large number of data set as my dataset. This dataset is about 800 printed images of Sinhala sentences and Sinhala words

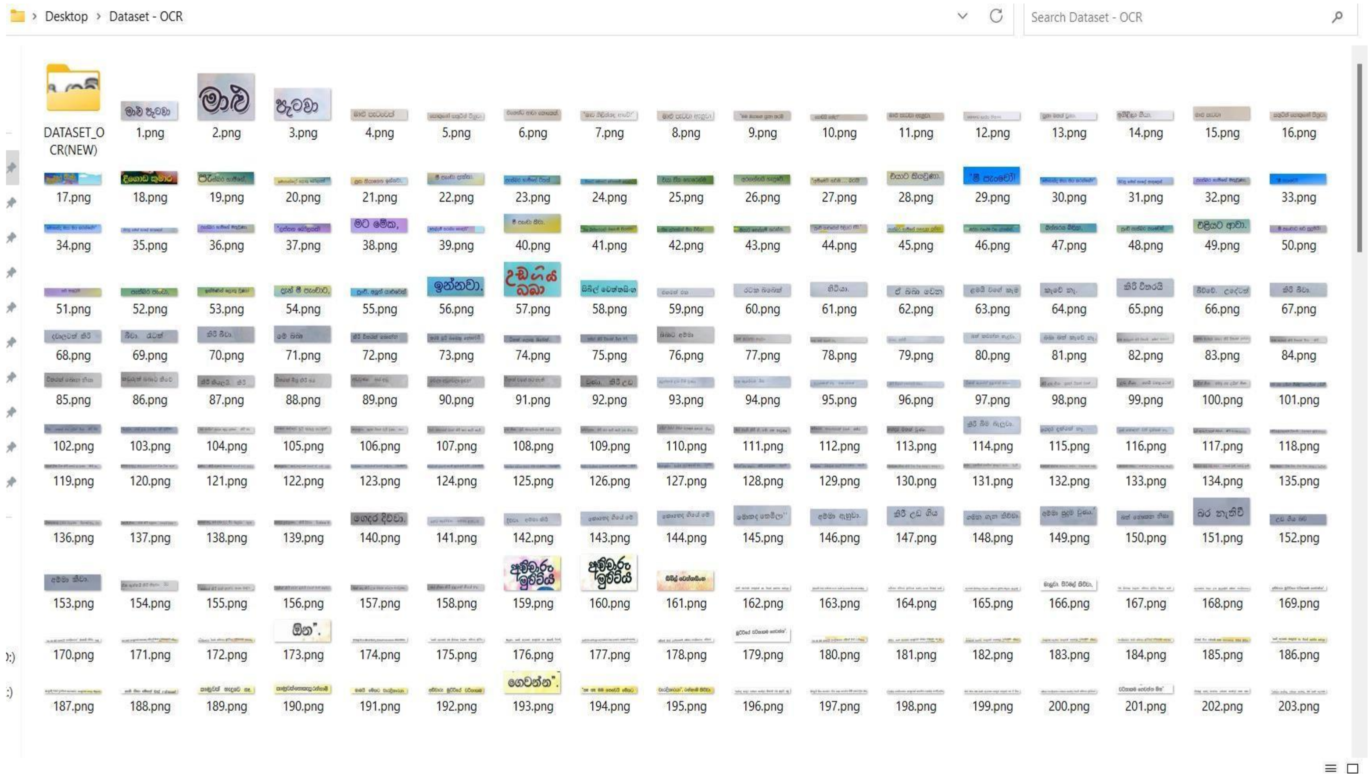

Figure 14:Customized OCR dataset

Then I made another dataset as the labeling of the collected dataset .

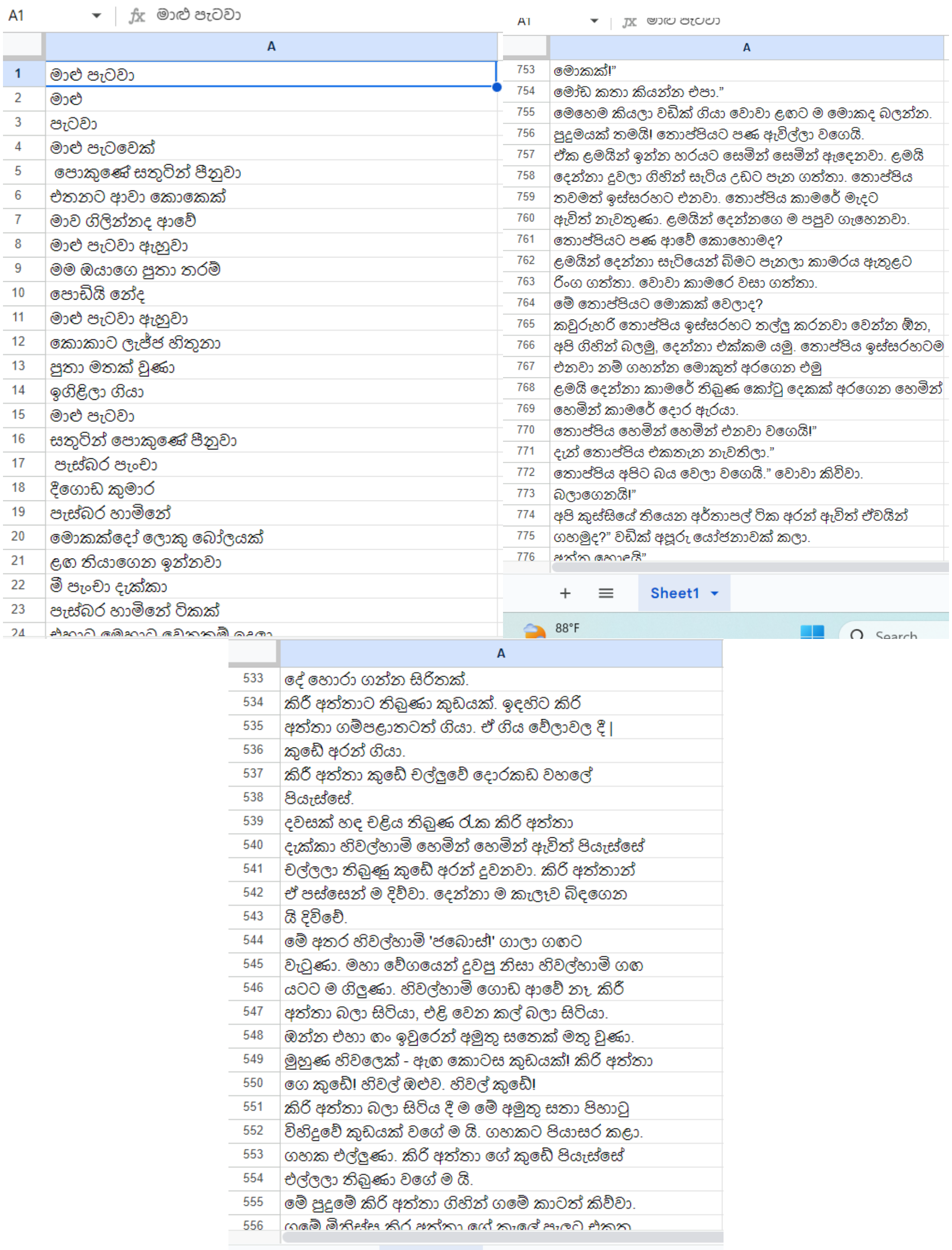

Figure 15:Customized labeled dataset

Here the dataset processing and training part :-

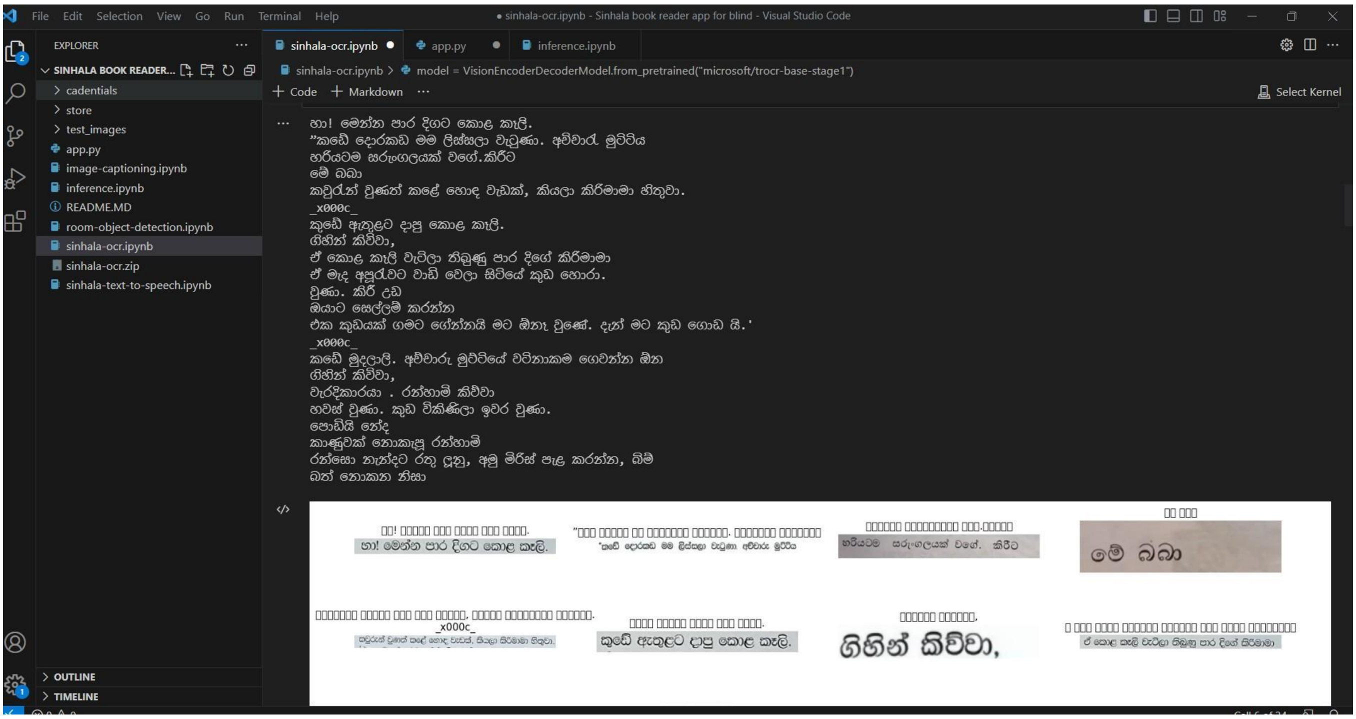

Figure 16:Dataset processing

Creating a customized dataset for OCR (Optical Character Recognition) involves several key steps to ensure the dataset is well-structured, diverse, and representative of the data you want to recognize. Here's a step-by- step guide on how to create a custom OCR dataset:

1. Define Dataset's Purpose:

Determine the specific objectives of the OCR system. What type of text or characters want to be recognized? Are you focusing on printed text, handwriting, or a combination of both? Knowing the dataset's purpose is essential for gathering the right data.

2. Data Collection:

Gather a diverse set of data that represents the variability you expect your OCR system to encounter in real-world scenarios. This may include: Printed text samples from books, magazines, and newspapers, Text samples in different fonts, sizes, and styles. Text samples with varying backgrounds and noise levels.

3. Data Preprocessing:

Prepare and preprocess the collected data to ensure consistency and quality: Resize and standardize image dimensions. Normalize image contrast and brightness. Convert images to a common format (e.g., JPEG or PNG). Remove unnecessary noise or artifacts from the images.

4. Annotation and Labeling:

Annotate each image to indicate the ground truth. This involves specifying the text content present in each image. Annotations should be accurate and complete. Store the annotations in a structured format, such as XML, JSON, or CSV, linking each image to its associated text.

5. Data Augmentation (Optional):

To increase dataset size and improve model robustness, consider applying data augmentation techniques such as rotation, scaling, flipping, and adding noise to create variations of your existing data.

6. Splitting the Dataset:

Divide your dataset into distinct subsets for training, validation, and testing. Common splits include 70% for training, 15% for validation, and 15% for testing. Ensure that each subset maintains the same distribution of data characteristics.

7. Dataset Balance:

Ensure that your dataset is balanced, meaning it has an even representation of different classes or characteristics you want to recognize. This helps prevent bias in the OCR system.

8. Quality Control:

Review the dataset for any labeling errors, inconsistencies, or outliers. Manually verify a random sample of images to ensure that annotations match the image content accurately.

9. Dataset Size:

The size of your dataset depends on the complexity of the recognition task. For deep learning-based OCR models, larger datasets are often beneficial. Aim for a dataset size that provides sufficient diversity and generalization.

10. Documentation:
Maintain clear documentation of your dataset, including details about data sources, image preprocessing steps, and annotation guidelines. Proper documentation ensures reproducibility and helps others understand your dataset.

11. Ethical Considerations:
Be mindful of privacy and copyright issues when collecting and using data. Ensure you have the necessary permissions to use any copyrighted or sensitive material.

12. Sharing and Collaboration (Optional):
If appropriate, consider sharing your dataset with the research community to encourage collaboration and further advancements in OCR technology. Creating a custom OCR dataset requires careful planning and attention to detail. The quality and diversity of your dataset play a crucial role in the success of your OCR system. Regularly update and refine your dataset as needed to improve model performance and adapt to changing recognition requirements.

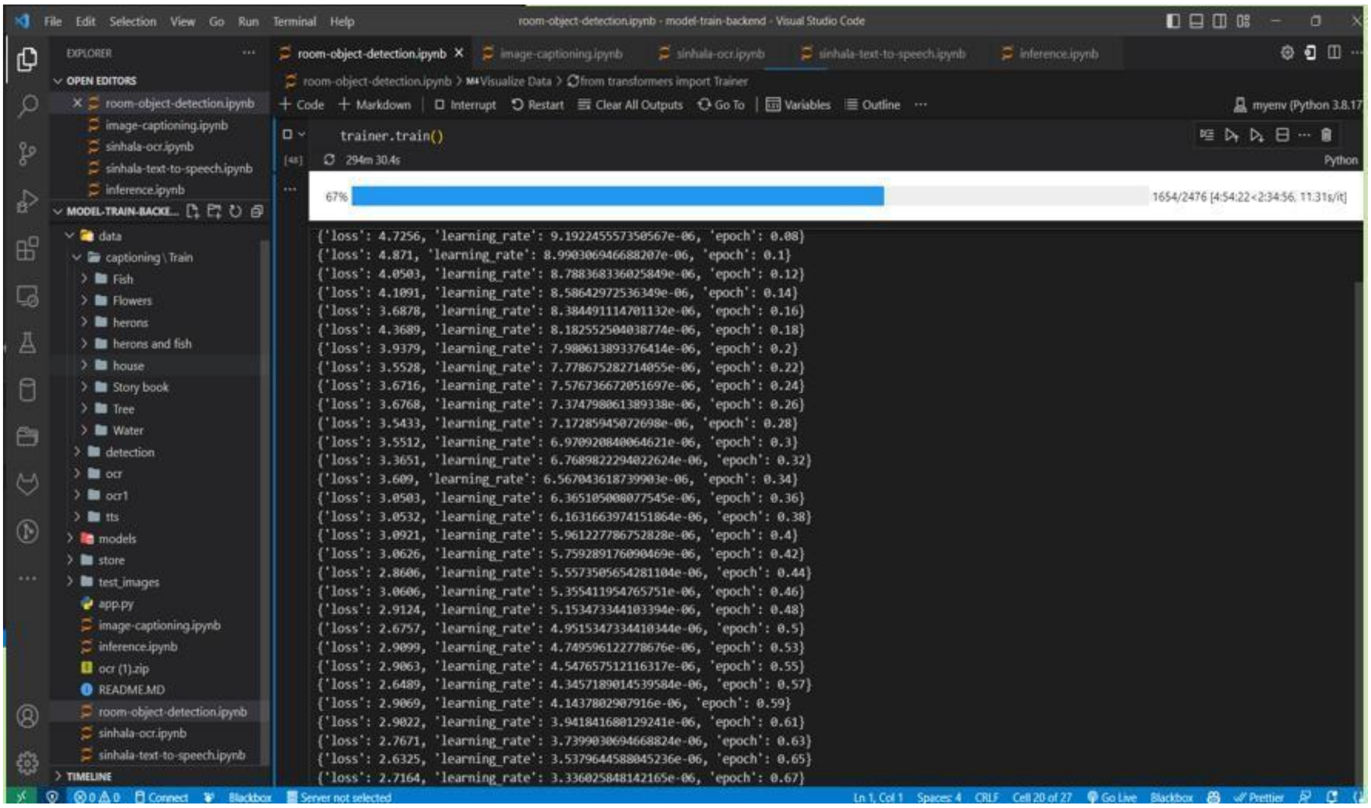

Figure 17:Data training

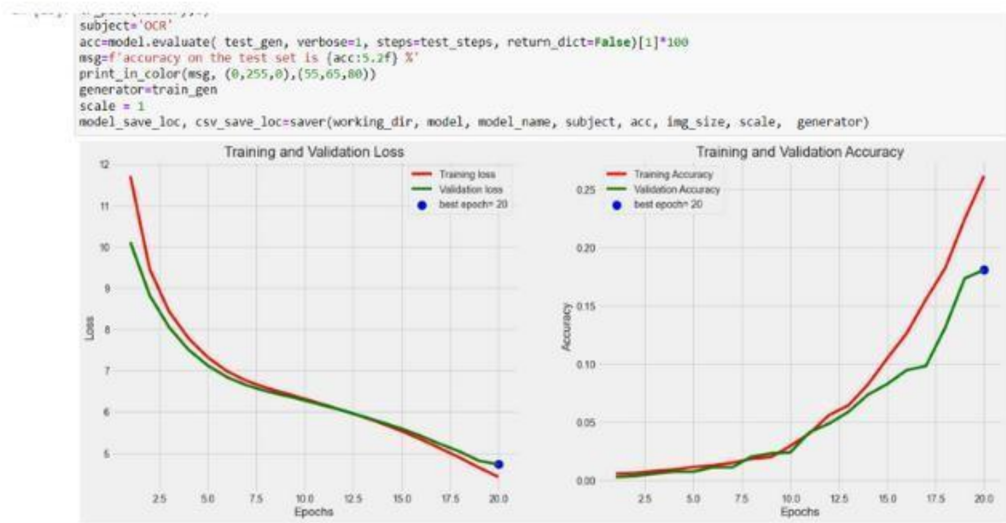

Figure 18:OCR accuracy chart

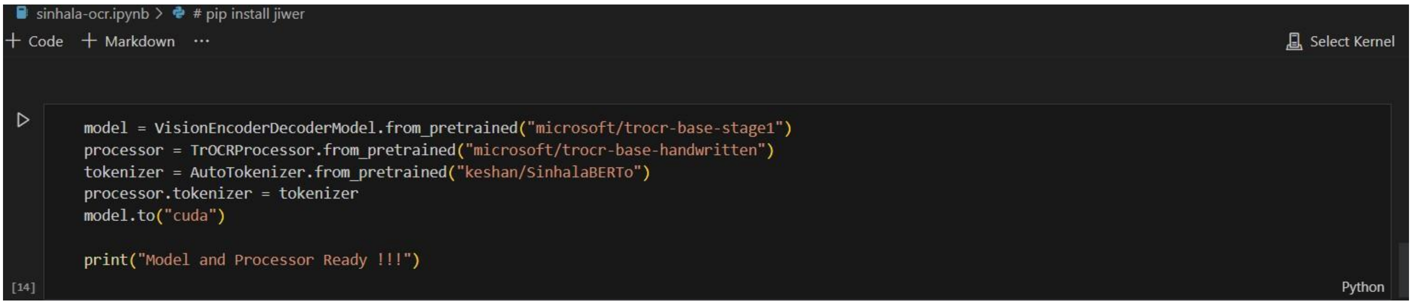

Figure 19:Used Models

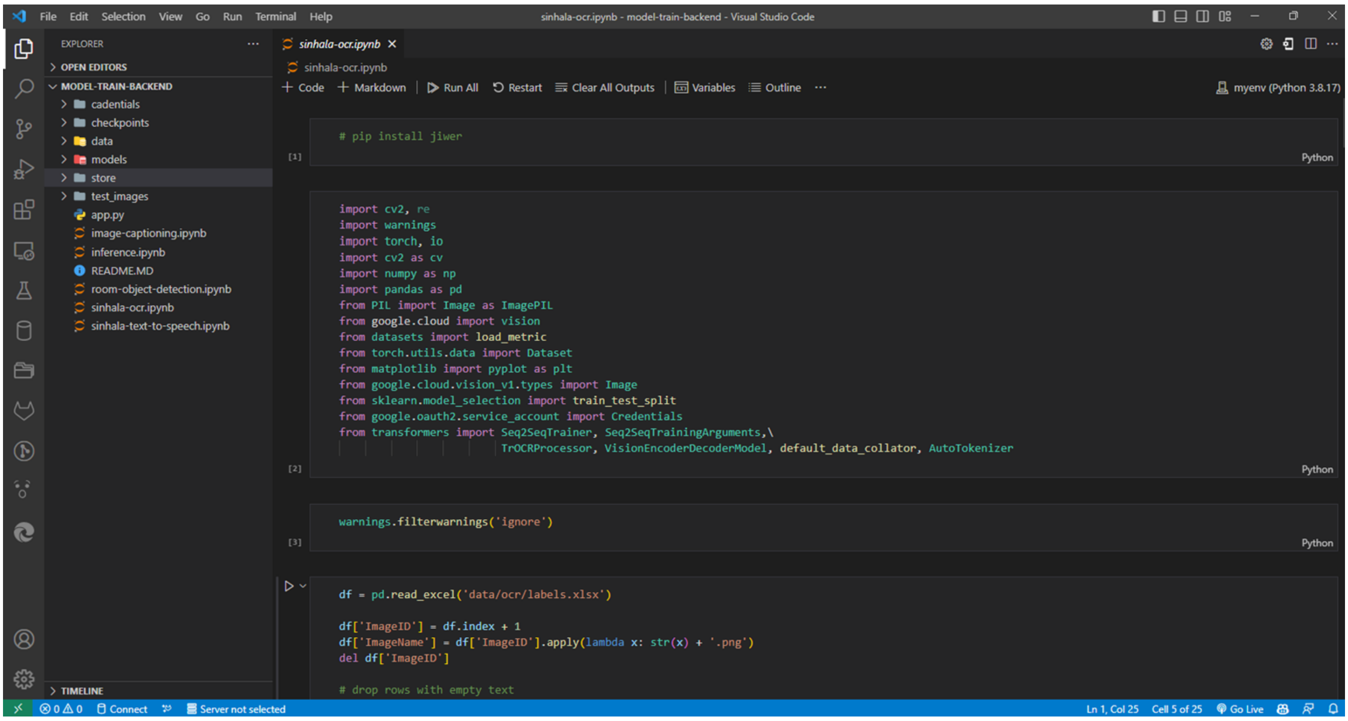

Figure 20:Imported libraries

3.3.2.2 Code Execution , tools and technologies

Explanation of the libraries , calling APIs' etc.

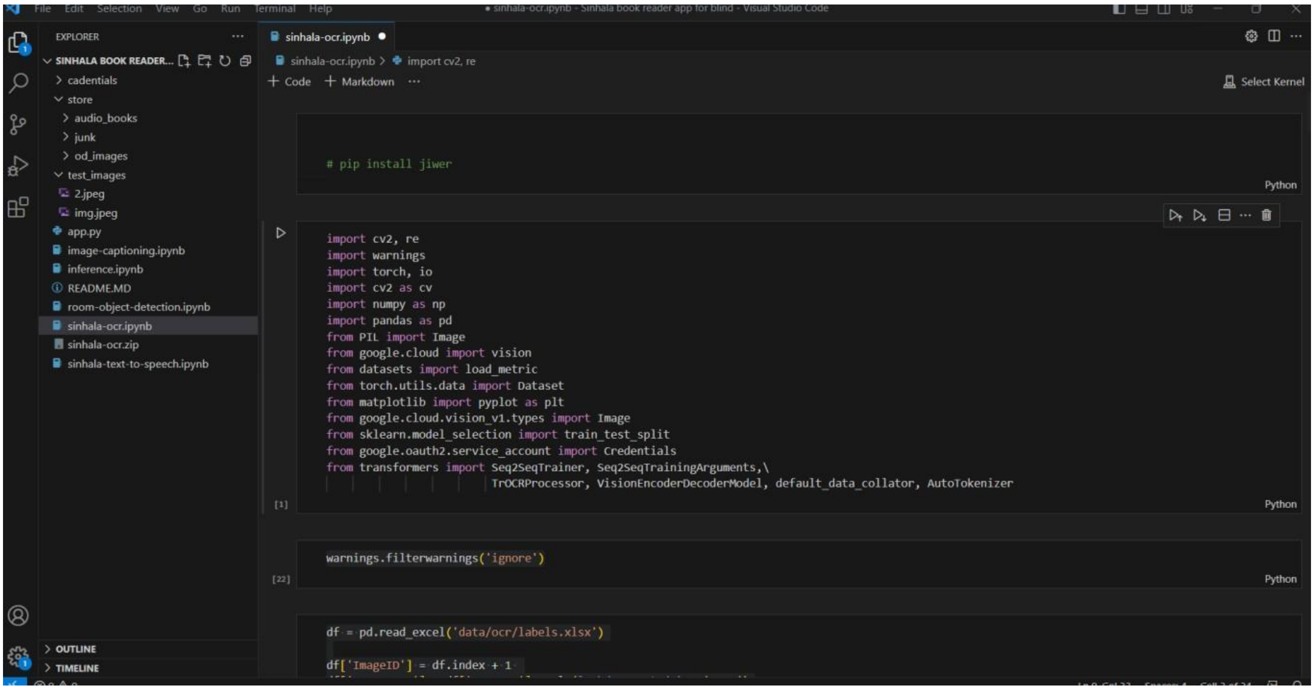

Figure 21:Libraries

Here several libraries are being imported and utilized for various tasks related to computer vision, natural language processing, and machine learning. The code begins by importing standard libraries like cv2 (OpenCV), warnings, torch (PyTorch), io, numpy, pandas, and re (regular expressions) to handle image processing, data manipulation, and text operations. Next, the code imports the Image module from both PIL (Python Imaging Library) and google.cloud.vision for image handling and processing.

For dataset manipulation and metric evaluation, it uses datasets to load metrics and defines a custom dataset class using torch.utils.data.Dataset. To visualize images, the code relies on matplotlib.pyplot.
For integration with Google Cloud Vision API and authentication, it imports google.oauth2.service_account.Credentials. Finally, the code utilizes the Hugging Face Transformers library,importing Seq2SeqTrainer, Seq2SeqTrainingArguments, TrOCRProcessor, VisionEncoderDecoderModel, default_data_collator, and AutoTokenizer. These components are essential for training and fine-tuning sequence-to-sequence models, particularly for Optical Character Recognition (OCR) tasks, using pre-trained models and custom data processing.

Overall, these libraries and modules come together to create a comprehensive environment for working with image-based text recognition, combining computer vision and natural language processing techniques within the context of machine learning.

Tools and technologies

Developing an OCR (Optical Character Recognition) system involves a combination of tools and technologies that enable the recognition and conversion of printed or handwritten text into machine-readable text. Here are the key tools and technologies commonly used in OCR development:

- OpenCV (Open Source Computer Vision Library): OpenCV is used for image acquisition, preprocessing, and basic image manipulation in OCR applications. It can help with tasks such as image enhancement, noise reduction, and image binarization.

- TrOCRProcessor : This processor is specifically tailored to handle OCR-related data, making it easier for developers to prepare their data for training, fine-tuning, or inference with OCR models.

- Tesseract OCR: Tesseract OCR is often integrated into OCR systems to perform character recognition on preprocessed images. It provides an API for easy integration into various programming languages.

- Google Cloud Vision API: Google Cloud Vision API offers cloud-based image analysis and OCR capabilities with high accuracy.

- Jupyter Notebook : This interactive development environment for running Python code, making them ideal for prototyping and experimenting with OCR models. Use these environments to write, test, and refine OCR algorithms, as well as visualize results.

- AutoML and Hyperparameter Tuning Tools: Automated Machine Learning (AutoML) tools and hyperparameter tuning platforms can automate the process of model selection and optimization, saving time and effort. These tools can be used to find the best OCR model architecture and hyperparameters for a specific task.

- Version Control Systems (e.g., Git): Version control systems help manage code repositories, track changes, and collaborate with team members. It, in particular, is essential for maintaining codebase integrity and collaborating on OCR project development.

3.4 Summary

This chapter addressed the overview system architecture of the designed work briefly. The individual contribution has been discussed broadly using the technologies used for the software implementations.

Chapter 04
RESULTS & DISCUSSIONS

Here are the main results of our mobile app. Using this first UI a user can login to the system by giving a Sinhala voice command :-

Figure 22:Home screen

Then it will navigate to an interface like this . Through this UI a user can give other voice commands in sinhala :-

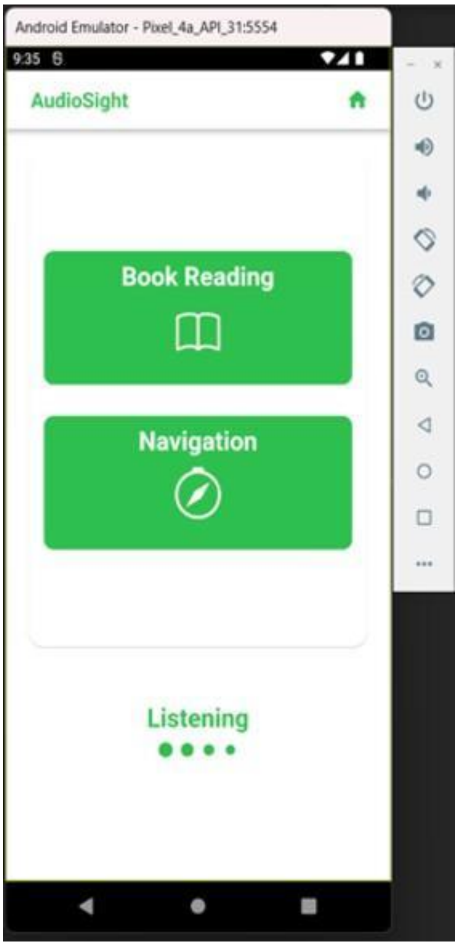

Figure 23:First navigated UI

Then the user can capture the page whatever he/she wants through the camera of the mobile phone . And then the OCR engine starts the process :-

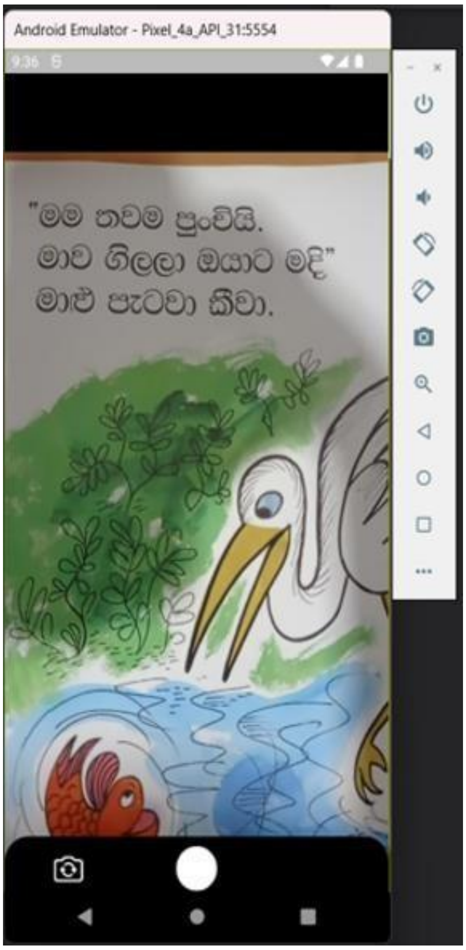

Figure 24:Image captioning

Then the user can listen to the book . The captured text from OCR will send that texts to the TTS :-

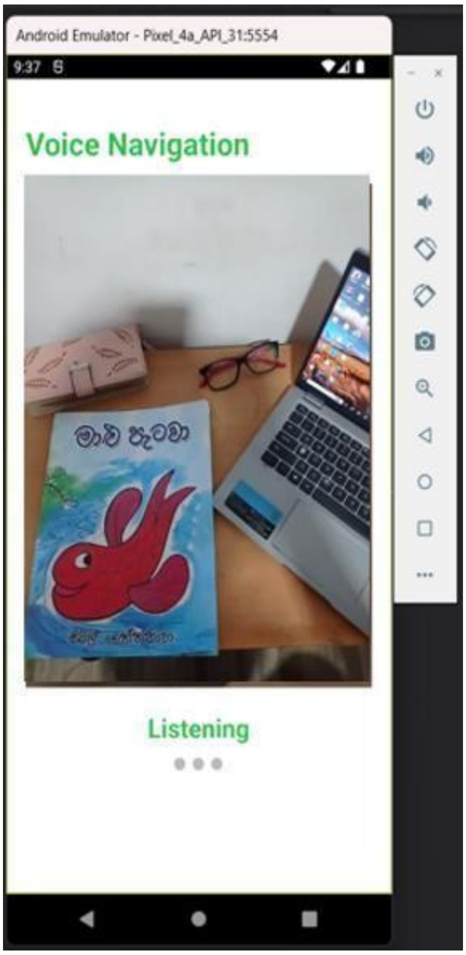

Figure 25:Output

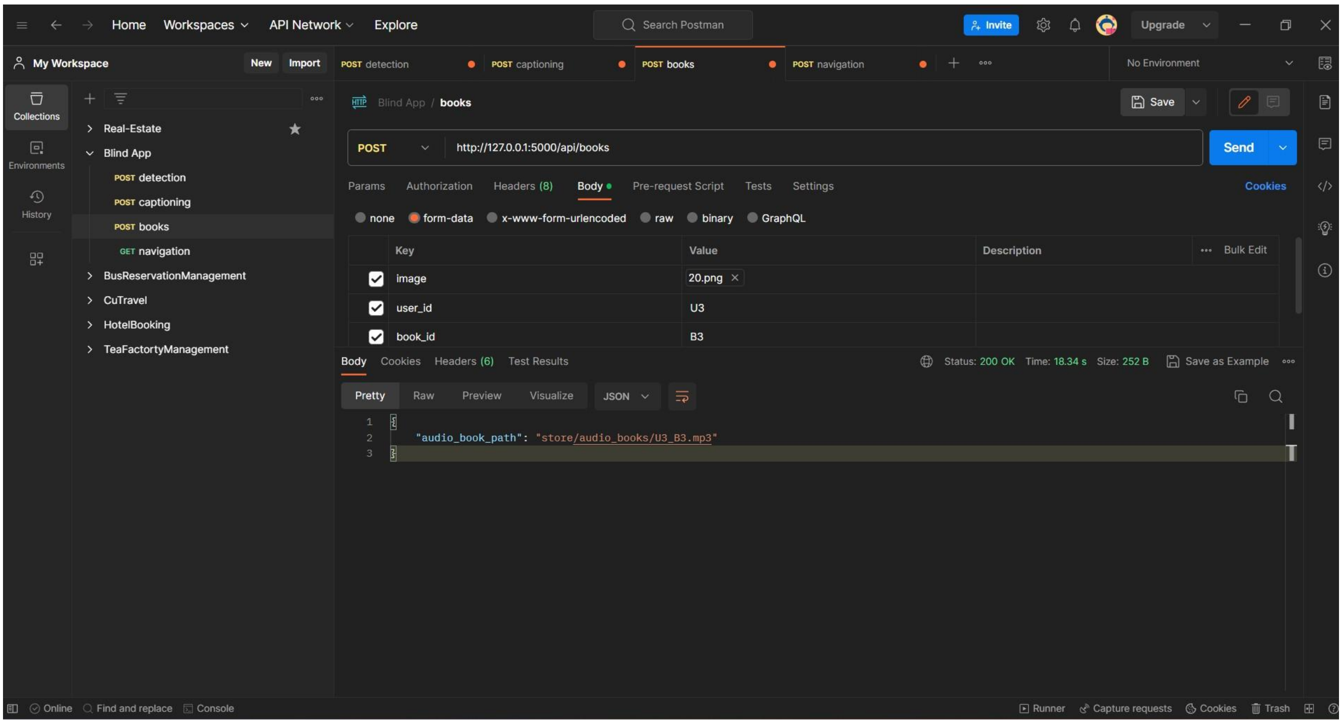

Figure 26:Postman backend API response for OCR

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Figure 27:Used commands for voice navigation

Testing and test cases for the OCR

Table 5:Testcase 01

Test Case ID	**TC_01**
Test Priority Level **(Low/Medium/High)**	High
Description	Verifying that the OCR is capturing Sinhala characters correctly or not
Pre-Condition(s)	User select the appropriate conditions
Test Procedure	Step1: Open “Audio Sight” app Step2: Go to the home page and give a Sinhala command . Step3: Capture the frame whatever you want Step4: Listen to the output
Test Input	Sinhala words containing image
Expected Output	1. OCR should identify Sinhala words correctly
Actual Output	1. OCR identifies the Sinhala words correctly
Test Status	Pass

Table 6:Testcase 02

Test Case ID	**TC_02**
Test Priority Level **(Low/Medium/High)**	High
Description	Verify that the user can correctly capturing the image for the OCR .
Pre-Condition(s)	User select the appropriate conditions
Test Procedure	Step1: Open "Audio Sight" app Step2: Go to the Home page Step3: Capture the image
Test Input	Sinhala words containing image
Expected Output	The user should be able to capture the Sinhala letters in the image
Actual Output	The can capture the Sinhala letters in the image
Test Status	Pass

Table 7:Testcase 03

Test Case ID	**TC_03**
Test Priority Level **(Low/Medium/High)**	High
Description	Verify the accuracy of OCR
Pre-Condition(s)	User select the appropriate conditions
Test Procedure	Step1: Open “Audio Sight” app Step2: Go to the Home page Step3: Capture the image Step 4: Compare the audio output with the input Sinhala words
Test Input	Sinhala words containing image
Expected Output	The pronunciation of the words should be similar to the words containing in the image .
Actual Output	The accurate level is good
Test Status	Pass

Table 8:Testcase 04

Test Case ID	**TC_04**
Test Priority Level **(Low/Medium/High)**	High
Description	Verify that the OCR send the output of captured Sinhala characters to the TTS on time
Pre-Condition(s)	User select the appropriate conditions
Test Procedure	Step1: Open “Audio Sight” app Step2: Go to the Home page Step3: Capture the image Step 4: Hear to the voice output
Test Input	Sinhala words containing image
Expected Output	The output voice should hear within a small time after capturing the image
Actual Output	The output voice is coming within a small time after capturing the image
Test Status	Pass

Chapter 05
CONCLUSION

In conclusion, the developed Sinhala book reader for visually impaired individuals with OCR represents a significant milestone in the realm of inclusive technology and accessibility. This application has successfully bridged the gap between visually impaired individuals and the rich world of Sinhala literature, empowering them with the tools and resources needed to access, engage with, and enjoy books in their native language. The combination of accurate Optical Character Recognition (OCR) and natural Text-to-Speech (TTS) synthesis has transformed printed text into a readily accessible auditory format, allowing users to immerse themselves in the literary treasures of Sinhala culture.

The application's intuitive user interface, tailored settings, and compatibility with various accessibility tools ensure that it accommodates the diverse needs and preferences of its users. From gesture-based controls to braille displays, from customizable text sizes to offline access, the application has been thoughtfully designed to provide a personalized and enriching reading experience. Education has been a primary focus, with features such as synchronized text highlighting and reading comprehension exercises supporting visually impaired students in their academic pursuits. The app has not only expanded their educational horizons but also fostered a sense of belonging through its community engagement features, including support forums and book clubs. Furthermore, the commitment to accessibility standards, data privacy, and continuous improvement underscores the application's dedication to enhancing the quality of life for visually impaired individuals. By providing them with a gateway to literature, knowledge, and cultural engagement, this app has not only broken down barriers but also empowered a marginalized community, opening doors to education, enrichment, and social connection. In summary, the Sinhala book reader for visually impaired individuals with OCR is a testament to the transformative power of technology in promoting inclusivity and equal access to the world of literature and learning.

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APPENDIX

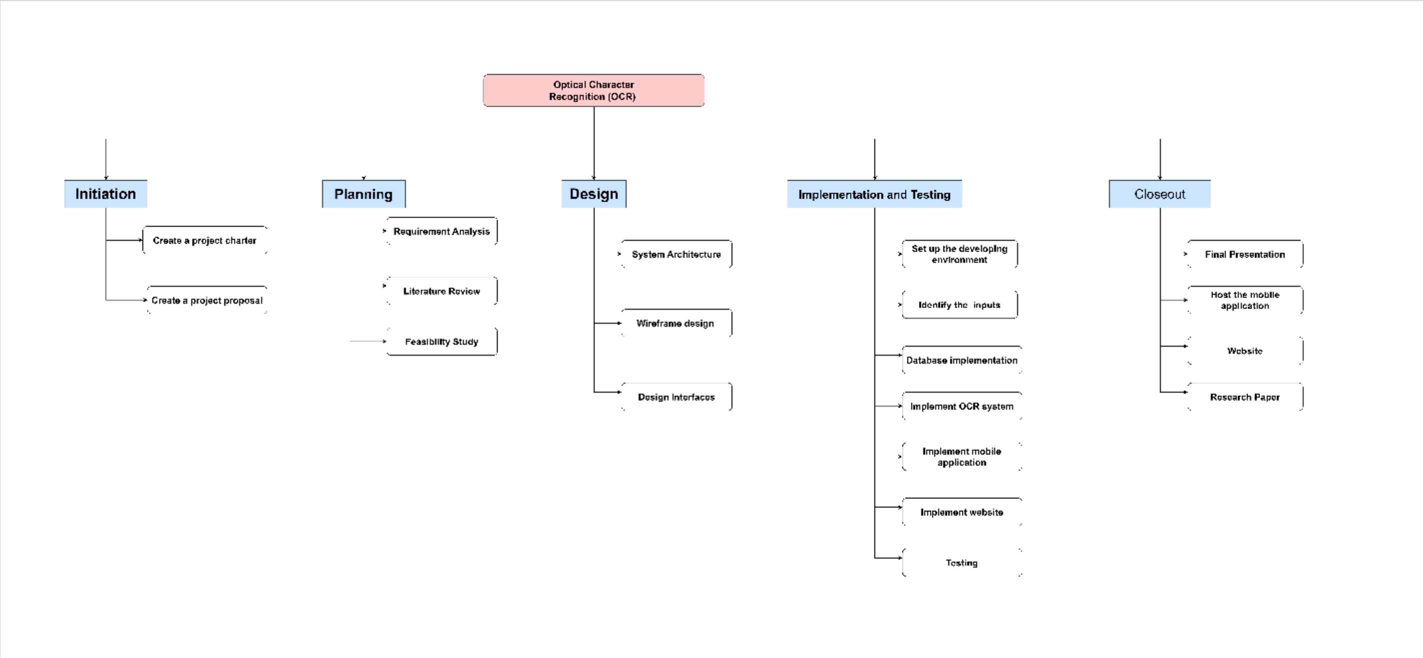

Figure 28:Work breakdown chart

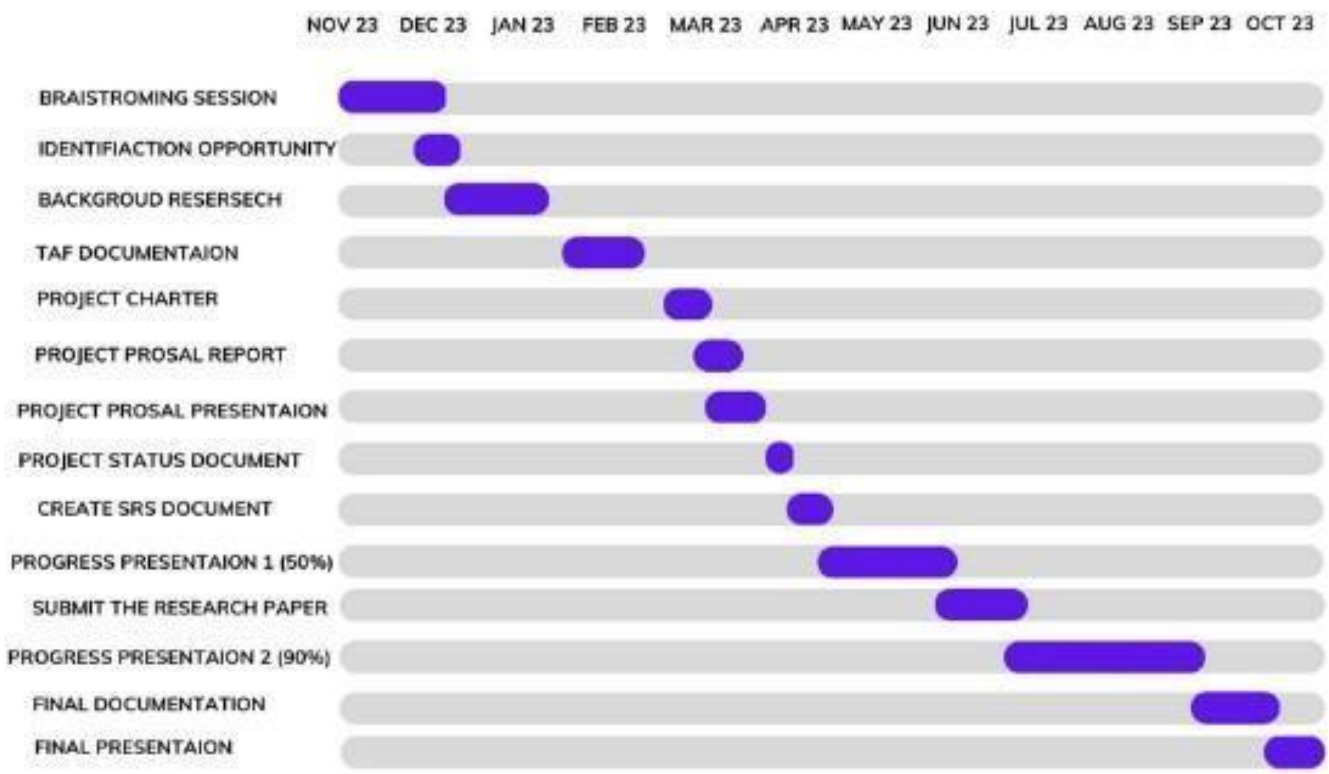

Figure 29:Grant chart