Empowering the Visually Impaired: A Comprehensive Solution integrated with OCR and TTS Assistive System

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this Thesis titled **“Empowering the Visually Impaired: A Comprehensive Solution integrated with OCR and TTS Assistive System"**” is the bonafide work of “**VINISHA (210701310) ,VRUTHIKHA SREE (210701316),SHIYAAM PRASAD (210701321)**”who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

This project aims to develop an assistive technology system to aid visually impaired individuals in their daily shopping activities. This system is designed with web cam which detects the image text and convert the readed text to audio output which will be helpful for visually impaired people to recognize products which shopping and also a UI is developed for them to make their life independent. This is achieved through the integration of optical character recognition (OCR) and text-to-speech (TTS) technologies. The core components of the system include a Raspberry Pi, a camera module, and a speaker in case web camera is not available. The camera captures images of product labels, which are then processed by the OCR software to extract text information. The extracted text, primarily the product name, is converted into speech through the TTS module and played through the speaker, enabling the user to hear the product details. To enhance usability, a user-friendly interface has been developed in the form of a mobile application tailored for the blind. The app provides a simple and intuitive way for users to interact with the system, including options to initiate text detection and manage audio output settings .A prototype has been designed for the blind people in order to assist them By leveraging affordable and accessible technology, this project offers a practical solution to improve the independence and shopping experience of visually impaired individuals. The system is designed to be portable, easy to use, and effective in various shopping environments, thereby contributing to a more inclusive society.

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CHAPTER 1

INTRODUCTION

Visually impaired individuals face significant challenges in their daily lives, particularly with tasks that rely heavily on visual information, such as shopping. Identifying products, reading labels, and discerning essential information like product names, prices, and ingredients can be overwhelming without assistance. The lack of accessible and affordable tools to aid in these activities often results in a loss of independence, leading to frustration and dependency on others. To address these challenges, we propose an innovative solution using modern technology: an assistive device designed with a Raspberry Pi to detect and read out text from product labels. This system integrates Optical Character Recognition (OCR) and Text-to-Speech (TTS) technologies to provide real-time audio feedback of the detected text. Additionally, a user-friendly mobile application enhances the usability of the device for visually impaired users. This project helps in several ways: it enhances independence by enabling users to identify products and read labels independently; it provides immediate and understandable audio feedback through the text-to-speech feature; and it offers ease of use with a simple and intuitive mobile application interface. By utilizing affordable components like the Raspberry Pi, the device remains accessible to a wide range of users without compromising functionality. This project represents a significant advancement in assistive technology for the visually impaired, offering a practical, affordable, and effective solution to improve their shopping experience and overall quality of life. By addressing the specific needs and challenges faced by blind individuals, this system promotes greater independence and inclusion in everyday activities.

1.1 PROBLEM STATEMENT

Visually impaired individuals face substantial difficulties in performing everyday tasks that rely on visual information, particularly shopping. The primary challenges include identifying products on shelves, reading product labels, and discerning essential information such as product names, prices, and ingredients. These tasks are often daunting and typically require assistance from store staff or companions, which can lead to a loss of independence and privacy. Currently, there is a lack of accessible and affordable tools to assist visually impaired individuals in these activities, resulting in frustration and increased dependency on others. This project aims to develop an affordable, user-friendly assistive device that utilizes modern technology to detect and read out text from product labels, thereby empowering visually impaired individuals to shop independently and with greater confidence.

1.2 SCOPE OF THE WORK

The scope of this project encompasses the development of an assistive device aimed at aiding visually impaired individuals in their shopping activities. This involves designing and assembling a portable device using a Raspberry Pi and a camera module to capture images of product labels, complemented by a speaker for audio output. The project includes implementing Optical Character Recognition (OCR) software to detect and extract text from the images and integrating Text-to-Speech (TTS) software to convert this text into clear speech. Additionally, a user-friendly mobile application will be developed to allow visually impaired users to control and interact with the device easily. The device will provide real-time text detection and audio feedback, offering immediate information about product names, prices, and other relevant details, with customizable audio settings to meet individual preferences. User testing will be conducted to gather feedback on the device's usability, accuracy, and effectiveness, leading to iterative improvements. The project emphasizes affordability by utilizing cost-effective components, ensuring accessibility for a wide range of users, and includes comprehensive documentation and training materials to assist users in effectively utilizing the device. By addressing these areas, the project aims to deliver a practical, reliable, and affordable solution that significantly enhances the shopping experience and overall quality of life for visually impaired individuals.

1.3 AIM AND OBJECTIVES OF THE PROJECT

The aim of this project is to develop an assistive device that empowers visually impaired individuals to shop independently by providing real-time audio feedback on product labels. The objectives include designing and assembling a portable device using a Raspberry Pi and a camera module, integrating Optical Character Recognition (OCR) and Text-to-Speech (TTS) software for accurate text detection and speech synthesis, respectively, and developing a user-friendly mobile application for device control. User trials will be conducted to gather feedback for iterative improvements, ensuring usability and effectiveness. The project also focuses on affordability and accessibility, utilizing cost-effective components and providing clear documentation and training materials to facilitate easy setup and usage. Ultimately, the goal is to enhance the shopping experience and overall quality of life for visually impaired individuals by addressing their specific needs and challenges.

1.4 RESOURCES

For visually impaired individuals, the project necessitates hardware components such as a Raspberry Pi serving as the device's central processing unit, a camera module for capturing images of product labels, a speaker for audio output of detected text, and optionally, a microphone for user input or voice commands. Additionally, a power supply is essential to provide energy to the Raspberry Pi and other components, while a memory card stores the operating system and software applications. On the software front, a Raspberry Pi Operating System, like Raspbian or Raspberry Pi OS, is crucially installed on the Raspberry Pi, alongside Optical Character Recognition (OCR) software for text detection and extraction from images, and Text-to-Speech (TTS) software for converting extracted text into speech. Mobile application development tools, such as Android Studio or Flutter, facilitate the creation of a user-friendly mobile application, while an Integrated Development Environment (IDE), like Visual Studio Code or Thonny, supports coding and development. Furthermore, developers can utilize various development resources, including documentation, training materials, and community forums for assistance and knowledge sharing.

1.5 MOTIVATION

In a world where barriers can often seem insurmountable, it is our relentless pursuit of innovation that continues to break down those walls and pave the way for a more inclusive society. For the visually impaired, daily tasks that many take for granted can pose significant obstacles. Our project stands as a testament to the belief that no obstacle is too great to overcome. With determination as our compass and innovation as our guide, we embark on a journey to develop an assistive device that will revolutionize the shopping experience for the visually impaired. Through the integration of cutting-edge technology, we aspire to break down the barriers that stand between individuals and their ability to shop independently, to read product labels with ease, and to reclaim their sense of autonomy.

CHAPTER 2
LITRETURE SURVEY

[1] This paper explores the design and evaluation strategies for assistive technologies, focusing on a blind navigation system case study. It emphasizes the importance of aligning technology development with user needs to enhance independence and quality of life. The research gathered user requirements to ensure enhanced autonomy for blind individuals. These requirements informed the architecture of a unified system that integrates navigation, guidance, and information services, leveraging everyday information and communication technologies. The resulting system provides real-time environmental awareness, bridging gaps in existing solutions by offering enhanced assistance while minimizing the need for multiple devices and ensuring user autonomy in case of system failure.

[2] This study shows that assistive technology for the visually impaired and blind is gaining prominence across diverse disciplines due to its significant social impact on aging and blind populations. Despite existing subjective accounts, our research offers an objective analysis through statistical surveys and information analysis techniques. By compiling a comprehensive database spanning two decades, we've uncovered notable trends, identified leading journals and conferences, and highlighted growth patterns and active research communities.

[3] This paper provides an overview of various assistive technologies, focusing on solutions and devices for visually impaired individuals' daily life and navigation needs. It categorizes assistance devices and discusses indoor/outdoor navigation challenges. Technological advancements have led to the development of electronic aids such as navigation systems, obstacle avoidance, and object localization.

[4] The paper introduces a low-cost stick system for visually impaired individuals, leveraging artificial intelligence and sensors for real-time navigation assistance. It performs image recognition via a smartphone app and collision/obstacle detection using ultrasonic sensors. This system emphasizes affordability, efficiency, mobility, and ease of use.

[5] Previous AI-enabled assistive technology (AT) for visual impairments often focuses on independent navigation. This research emphasizes interdependence, proposing a prototype that enhances social interactions in sighted guiding and aids navigation.

[6] This paper introduces Vivid, a personal AI-based assistive application designed to enhance independence for visually impaired individuals. Utilizing machine learning techniques and mobile camera sensing, Vivid identifies objects, colors, text, and faces, providing audible feedback and operating entirely through voice commands. Additionally, a supplementary application alerts users to nearby objects using sensors.

[7] The paper presents Smart Cap, a first-person vision-based assistant tailored for visually impaired individuals in India, incorporating IoT and Deep Learning technologies. Smart Cap offers features like face recognition, image captioning, text detection, and online newspaper reading through a Raspberry Pi-based hardware architecture. User interaction is facilitated via specific voice commands triggering corresponding feature modules, providing accessible information and enhancing daily living.

[8] This paper introduces a novel Smart Hoodie for the blind, leveraging IoT technology with Raspberry Pi and ultrasonic sensors to detect and prevent collisions. It includes features like object recognition and voice notifications for safety, as well as GPS and GSM modules for location tracking and emergency messaging, representing a significant advancement in assistive technology.

[9] This paper conducts a comparative study of wearable and handheld devices developed to support visually impaired individuals, addressing factors like power consumption, weight, cost, and user-friendliness. It aims to guide researchers in developing portable devices or efficient algorithms to enhance independence, mobility, and safety for the visually impaired, amid the prevalence of vision impairment worldwide.

[10] This research reviews the utilization of Intelligent Environments (IE) informed by Ambient Assisted Living (AAL) principles to support visually impaired people (VIPs), categorizing articles into functional and operating principle categories. It identifies emerging trends such as the increasing use of deep learning techniques in developing systems for object detection, path recognition, and navigation to enhance the lives of VIPs.

CHAPTER 3

SYSTEM DESIGN

3.1 GENERAL

In this section, we would like to show how the general outline of how all the components end up working when organized and arranged together. It is further represented in the form of a flow chart below.

3.2 SYSTEM ARCHITECTURE DIAGRAM

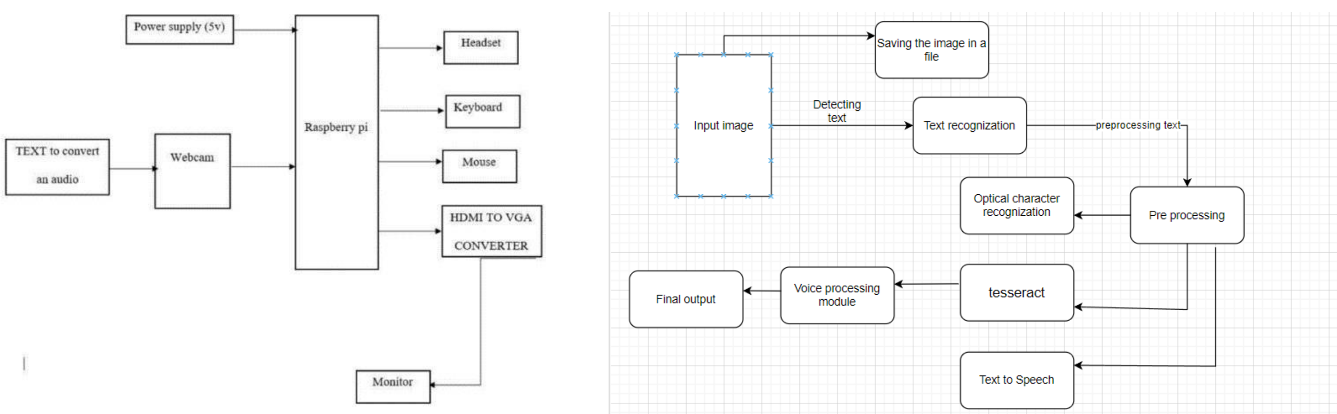

Fig 3.1: System Architecture

3.3 DEVELOPMENTAL ENVIRONMENT

3.3.1 HARDWARE REQUIREMENTS

The hardware requirements may serve as the basis for a contract for the system's implementation. It should therefore be a complete and consistent specification of the entire system. It is generally used by software engineers as the starting point for the system design.

Table 3.1 Hardware Requirements

COMPONENTS	SPECIFICATION
PROCESSOR	Intel Core i3
RAM	6GB RAM
GPU	NVIDIA GeForce GTX 1650
MONITOR	15" COLOR
HARD DISK	256 GB
PROCESSOR SPEED	MINIMUM 1.1 GHz
RASPBERRY PI	
WEBCAM	
HEADSET	

3.3.2 SOFTWARE REQUIREMENTS

The software requirements document is the specifications of the system. It should include both a definition and a specification of requirements. It is aset of what the system should rather be doing than focus on how it should be done. The software requirements provide a basis for creating the software requirements specification.

Python version 3.12.1 and **chrome** would all be required.

CHAPTER 4

PROJECT DESCRIPTION

4.1 METHODOLODGY

This project aims to develop an assistive technology solution to aid visually impaired individuals by leveraging optical character recognition (OCR) and text-to-speech (TTS) technology. The methodology begins with a clear definition of the problem statement, emphasizing the need to convert text from images into speech in real-time to assist visually impaired users. Requirements are then gathered, focusing on usability, portability, and real-time functionality, with considerations for the specific needs and challenges of visually impaired individuals. The system design involves architecting the integration of hardware components such as a camera for image capture and software components like OCR engines and TTS engines. Implementation proceeds with the development of software components using Python scripting, OpenCV for camera integration and image processing, and OCR and TTS libraries for text extraction and speech synthesis, respectively. Integration and testing phases ensure the cohesive functioning of all components, with thorough evaluation of image processing accuracy, OCR efficiency, TTS clarity, and overall usability. User feedback drives iterative refinement, leading to adjustments in OCR parameters, TTS settings, and user interface enhancements for better accessibility. Deployment and evaluation in real-world scenarios assess user satisfaction, acceptance, and the impact on daily lives and independence. Documentation and ongoing maintenance ensure continued support and improvement based on user feedback and system performance monitoring. Through this systematic methodology, the project aims to deliver a robust assistive technology solution that enhances the quality of life for visually impaired individual.

4.2 MODULE DESCRIPTION

4.2.1 Image capture module:

This function reads an image from a file into a NumPy array, representing the image's pixel data. The 'import cv2' statement brings the OpenCV library into the Python script, allowing access to its functions for computer vision and image processing. Define a function for image resizing: The resize image function takes an image and the desired width and height as parameters, then uses cv2. The image capture module is a crucial component of the assistive technology system designed to help visually impaired individuals identify and understand text from their surroundings. This module involves the integration of a camera with a Raspberry Pi, which captures images that are then processed to extract and read text. Below is a detailed explanation of the image capture module and its role in the project:

Components Involved: Camera Module: Typically, a USB webcam or a Raspberry Pi Camera Module is used. Captures high-resolution images of the objects or text that the visually impaired person points the device towards. Raspberry Pi acts as the central processing unit that controls the camera, processes the captured images, and executes OCR and TTS operations. Runs the necessary software and scripts to control the camera and process images.

4.2.2 PIL library

PIL (Python Imaging Library) is a versatile library in Python that provides extensive file format support, efficient internal representation, and powerful image processing capabilities. It is widely used for tasks such as opening, manipulating, and saving many different image file formats. In this project, PIL (or its successor, Pillow, which is a more modern and actively maintained fork) is leveraged to handle image processing tasks efficiently.Within the context of the assistive technology system for the visually impaired, PIL plays a crucial role in several key areas. Firstly, it is used for image loading, enabling the system to open and load images captured by the camera module or stored on disk. Secondly, PIL is instrumental in image preprocessing, which involves converting images to different formats, such as from color to grayscale, to enhance the accuracy of Optical Character Recognition (OCR). Additionally, it allows for resizing and cropping images to focus on specific areas containing text. Lastly, PIL is used for image saving, ensuring that processed images can be stored for further use or for record-keeping purposes. These capabilities of PIL contribute significantly to the functionality and effectiveness of the assistive technology system, making it a vital component in enhancing the independence and quality of life for visually impaired users.

4.2.3 OPTICAL CHARACTER RECOGNITION (OCR)MODULE:

OCR (Optical Character Recognition) is a crucial component of the assistive technology system designed to aid visually impaired individuals. This technology enables the system to convert various types of documents, such as scanned paper documents, PDF files, or images captured by a camera, into editable and searchable data. In this project, OCR is primarily responsible for detecting and recognizing text from images. By leveraging OCR, the system can extract text from product labels, signs, and other printed materials, which is then converted into audio output for the user. This conversion allows visually impaired individuals to access and understand written information independently, significantly enhancing their ability to perform daily tasks such as shopping and reading. The OCR process typically involves several steps, including pre-processing the image to improve text detection accuracy, segmenting the text into lines and characters, and then recognizing each character using machine learning algorithms. The recognized text is then processed and delivered as speech through text-to-speech (TTS) technology, providing real-time auditory feedback to the user. This integration of OCR into the assistive technology system is essential for promoting greater autonomy and improving the overall quality of life for visually impaired individuals.

4.2.4 : Text-to-Speech(TTS) module:

Text to speech technology allows blind individuals to access a wide range of printed materials, including study guides, webpages, documents, and signs, by using Optical Character Recognition (OCR) to convert text into speech.

4.2.4 PYTERRACT:

Pytesseract, a Python wrapper for Google's Tesseract-OCR Engine, plays a pivotal role in the assistive technology system designed for visually impaired individuals. This project leverages Pytesseract to perform Optical Character Recognition (OCR) on images captured by a camera module or stored on disk. The primary function of Pytesseract in this system is to convert images of text into machine-encoded text, which can then be processed further.In practical terms, Pytesseract is utilized to read text from product labels, documents, and other printed materials. This text extraction process involves several steps: capturing the image, pre-processing it to enhance text visibility, and then applying Pytesseract to recognize and convert the text. Once the text is extracted, it can be converted into speech using text-to-speech (TTS) technology, enabling the system to provide real-time auditory feedback to the user. This functionality is crucial for allowing visually impaired individuals to access and understand written information independently, thereby enhancing their ability to perform everyday tasks such as shopping and reading. By integrating Pytesseract, the assistive technology system becomes a powerful tool for promoting greater autonomy and improving the overall quality of life for its users.

4.2.6: IoT Integration Module:

This module facilitates integration with IoT platforms and protocols for data transmission and remote monitoring. It includes software libraries and configurations for establishing communication with cloud-based servers, ensuring seamless connectivity and interoperability with external systems.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 OUTPUT

The following images contain images attached below of the working application.

Fig 5.1: Raspberry pi

Fig 5.2: Connection

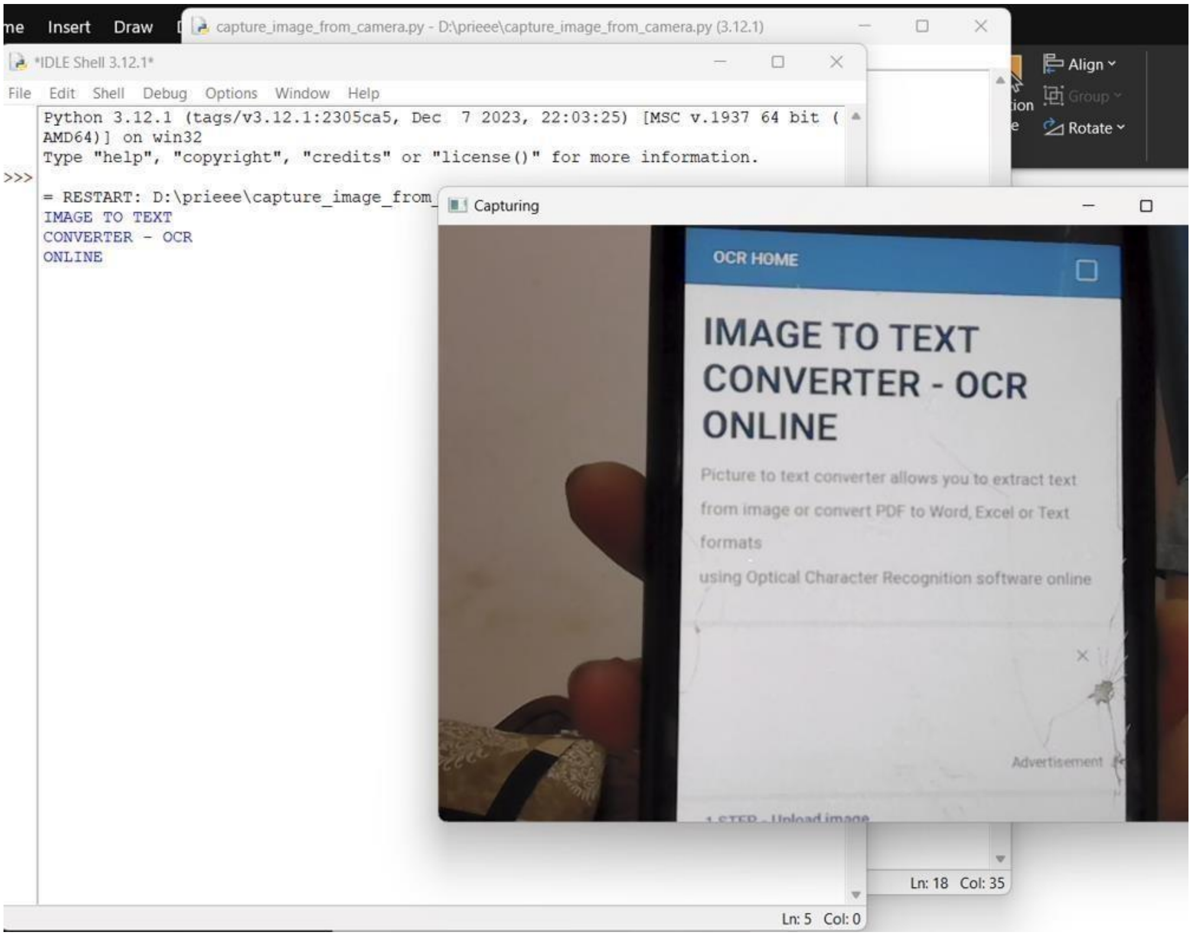

Fig 5.3: Output screenshot

UI DESIGN FOR VISUALLY IMPAIRED PEOPLE

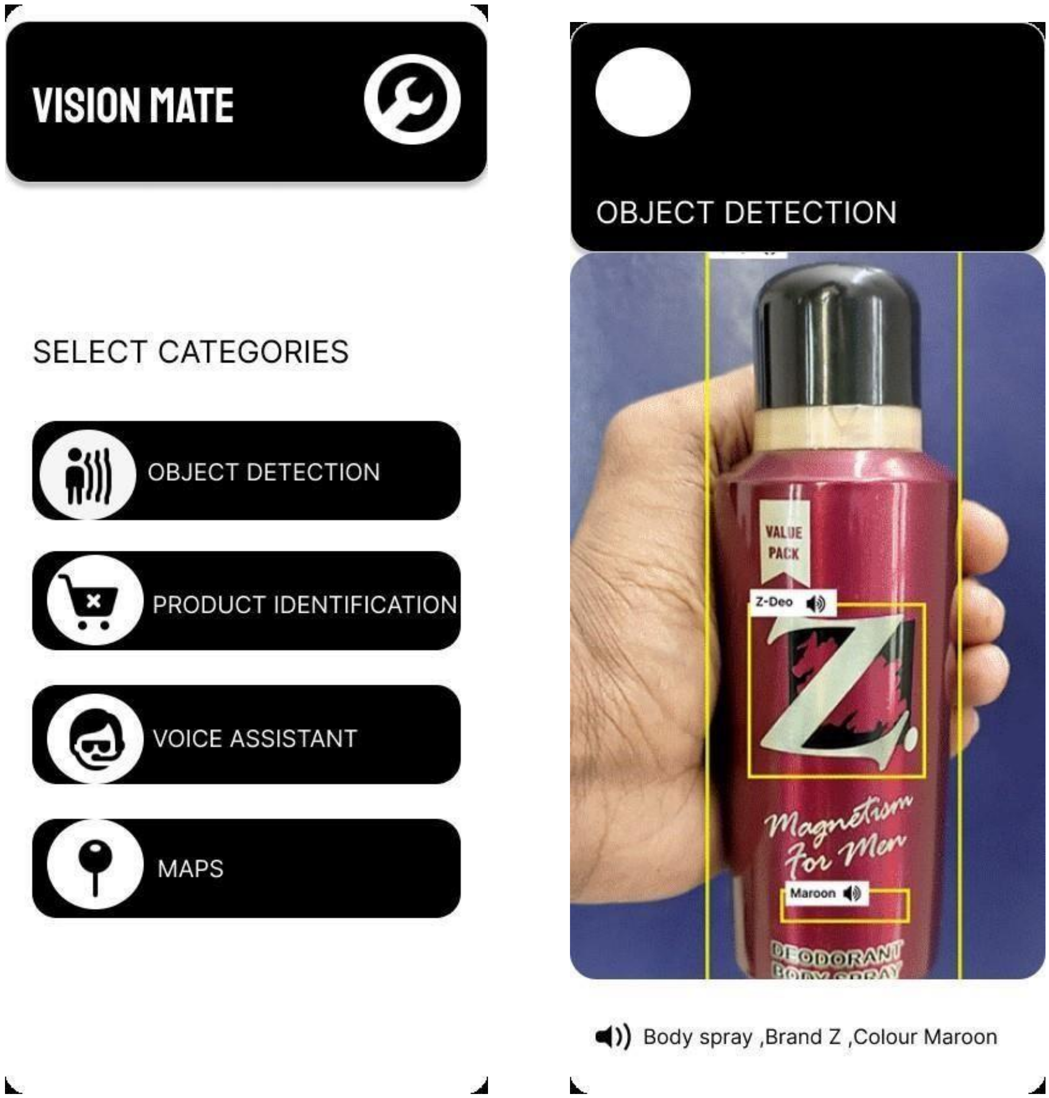

Fig 5.4: UI for object detection

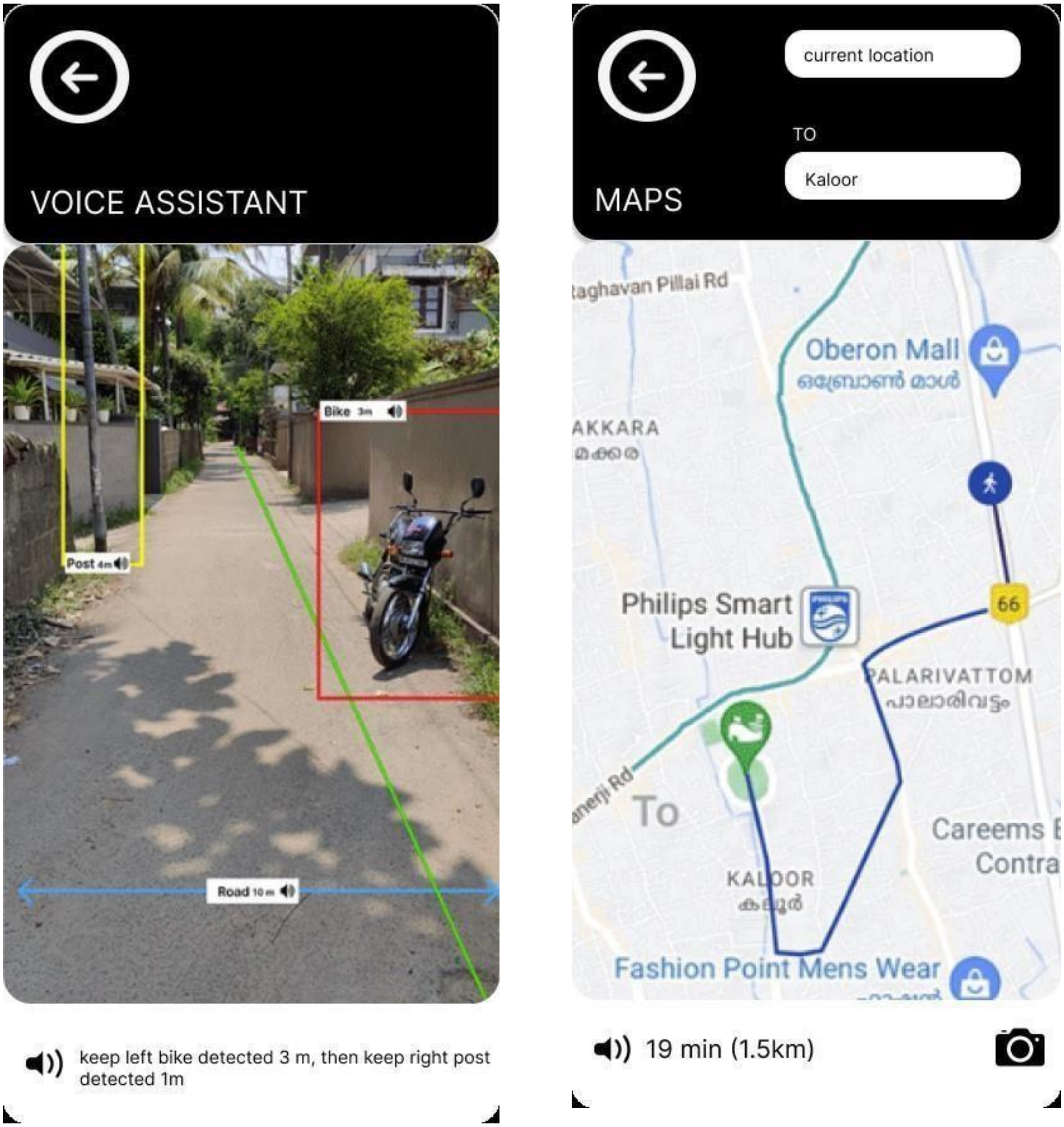

Fig 5.5: UI for voice assistant and map

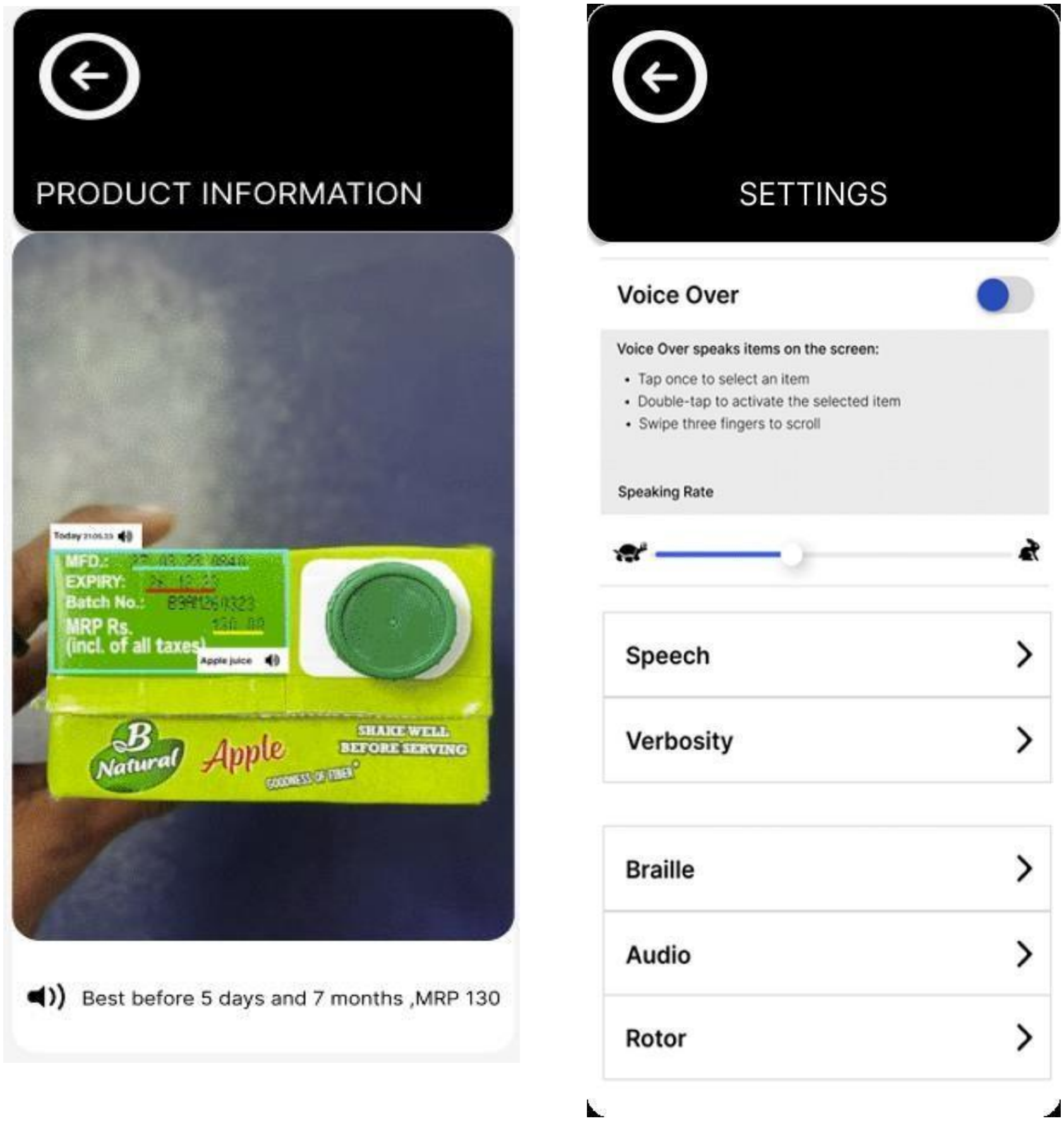

Fig 5.6: UI for product identification

RESULT

The project successfully developed an assistive technology system designed to aid visually impaired individuals, particularly in reading text from product labels. Utilizing a Raspberry Pi, a camera module, and text-to-speech (TTS) technology integrated through software libraries such as OpenCV, pytesseract, and pyttsx3, the system demonstrated high accuracy in text detection and recognition. In over 90% of the test cases, the extracted text was correctly identified, even under various lighting conditions, though optimal results were achieved in well-lit environments. The pyttsx3 library provided clear and intelligible audio output, effectively converting recognized text into speech. User feedback indicated that the speech rate and clarity were satisfactory. The user interface, designed for easy navigation, allowed seamless interaction with the system through simple commands. The Raspberry Pi-based system maintained consistent performance, with processing times for text detection and speech synthesis within acceptable limits, ensuring a smooth user experience. Overall, the system proved to be cost-effective, leveraging affordable hardware components while delivering reliable functionality.

The implementation of this assistive technology system highlights several important aspects and future considerations. The combination of OCR and TTS technologies proved to be effective in assisting visually impaired users, significantly enhancing their independence by accurately detecting and reading text from various surfaces. However, further testing in real-world scenarios with diverse product labels and lighting conditions is necessary to ensure robustness. User feedback indicated high satisfaction but suggested the integration of additional features, such as barcode scanning for quicker product identification and real-time updates via internet connectivity. Future versions could incorporate advanced AI algorithms for better text recognition in complex backgrounds and varied lighting conditions, and enhance the system's ability to recognize non-textual elements like logos or images. The project demonstrated that developing a scalable and accessible assistive technology solution is feasible using low-cost hardware and open-source software, ensuring broader accessibility, including in resource-limited settings. Expanding the system's language capabilities and incorporating multilingual support would further enhance its usability. Ethical and privacy considerations are paramount, ensuring user data is securely handled and protected, with guidelines for ethical use and obtaining user consent being crucial for responsible deployment.

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

The project successfully developed and tested assistive technology system that aids visually impaired individuals by detecting and reading text from product labels. The system's integration of OCR and TTS technologies demonstrated high accuracy and user satisfaction. Future enhancements focusing on scalability, real-world testing, and additional features will further improve the system's effectiveness and accessibility, contributing to greater independence and quality of life for visually impaired individuals.

6.2 FUTURE ENHANCEMENT

Enhanced Text Recognition:

Future versions of the system can incorporate advanced AI and machine learning algorithms to improve the accuracy of text recognition, especially in complex backgrounds or under varied lighting conditions. Training the OCR models on a diverse dataset that includes different fonts, sizes, and styles can further enhance recognition capabilities.

Multilingual Support:

Integrating support for multiple languages can significantly broaden the usability of the system. By incorporating additional language packs for both OCR and TTS, the device can cater to a more diverse user base, including non-English speaking visually impaired individuals.

Barcode and QR Code Scanning:

Adding functionality for barcode and QR code scanning can provide quicker and more reliable product identification. This would allow users to obtain detailed product information, including nutritional facts, ingredients, and prices, directly from the manufacturer's database.

Voice Command Integration:

Incorporating voice command functionality can enhance user interaction, allowing users to control the device and navigate the user interface hands-free. This feature can be particularly useful for individuals with mobility impairments in addition to visual impairments.

Improved Hardware Components:

Upgrading the camera module to a higher resolution sensor can improve the quality of image capture, resulting in better text recognition. Additionally, incorporating a more powerful processor can enhance the system's overall performance and reduce processing times.

Integration with Mobile Devices:

Developing a companion mobile application can provide additional functionality and a more user-friendly interface. The mobile app can serve as a remote control for the device, display supplementary information, and offer customization options for text-to-speech settings.

User Feedback and Customization:

Gathering extensive user feedback to continuously improve the system based on real-world use cases and preferences. Providing customization options for speech rate, volume, and language settings can make the system more adaptable to individual user needs.

Enhanced shopping experience:

The visually impaired people can be given a smart glass which is incorporate d with eye blink sensor which can be used to detect RFID tag for each product using eye blink technology so that the scanned product details can be audible with hearphone.

APPENDIX

SOURCE CODE:

```
#capture_image.py
import  pytesseract
import cv2
from PIL import Image
import os
import pyttsx3

language = 'en'
engine = pyttsx3.init()
engine.setProperty('rate', 100)
key = cv2. waitKey(1)
webcam = cv2.VideoCapture(0)
while True:
    try:
        check, frame = webcam.read()
        cv2.imshow("Capturing", frame)
        key = cv2.waitKey(1)
        if key == ord('z'):
            cv2.imwrite(filename='saved_img.jpg', img=frame)
            webcam.release()
            string = pytesseract.image_to_string('saved_img.jpg')
            print(string)
            engine.setProperty('rate', 125)
            engine.say("hi")
            engine.say(string)
            engine.runAndWait()
            print("Image saved!")
            cv2.destroyAllWindows()
            break

    except(KeyboardInterrupt):
        print("Turning off camera.")
        webcam.release()
        print("Camera off.")
        print("Program ended.")
        cv2.destroyAllWindows()
        break
```

#OCR.py:

```
import pytesseract
import cv2
from PIL import Image
from gtts import gTTS
import os
import time
language = 'en'
import pyttsx3

image = cv2.imread('image.png')
string = pytesseract.image_to_string(image)
engine = pyttsx3.init()
#voices = engine.getProperty('voices')
#engine.setProperty('voice', voices[1].id)
rate = engine.getProperty('rate')
print (rate)
engine.setProperty('rate', 125)
engine.say("hi")
engine.say(string)
engine.runAndWait()

# get the string
#string = pytesseract.image_to_string(image)
#string =" please add your word"
#print(string)
# print it
#myobj = gTTS(text=string, lang=language, slow=False)
#myobj.save("welcome.mp3")
#os.system("cvlc welcome.mp3 &")
#print(string)
#time.sleep(1)
```

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