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Intelligent Reader For Visually Impaired Person

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Abstract—This paper presents the development and implementation of an intelligent reader system designed to assist visually impaired individuals in accessing printed information. Leveraging Raspberry Pi technology and a push-button interface, the system integrates a high-resolution camera module for image capture, Optical Character Recognition (OCR) software for text extraction, and a text-to-speech engine for audio output. The system's functionality and performance were evaluated, demonstrating reliable image processing and speech synthesis capabilities. User feedback highlighted the system's intuitive design and potential for enhancing autonomy and participation in various contexts. Future developments aim to further improve accuracy and speed of text extraction, enhance speech synthesis quality, and incorporate advanced features such as real-time translation. Ethical considerations regarding privacy, data security, and inclusive design were carefully addressed throughout the project. Overall, the intelligent reader system represents a promising step towards creating a more accessible and inclusive environment for visually impaired individuals.

Keywords— Visually Impaired, Raspberry Pi, Intelligent Reader, Accessibility, Assistive Technology, Optical Character Recognition (OCR), Text-to-speech (TTS), Push button interface, Inclusive Design.

I. Introduction

Visual impairment poses significant challenges to individuals in accessing printed information, limiting their independence and participation in various aspects of life. Despite advancements in technology, many visually impaired individuals still encounter barriers when it comes to reading printed materials such as books, documents, and product labels. Traditional solutions, such as Braille and audio books, have provided valuable alternatives, but they often come with limitations such as availability, cost, and usability. In response to these challenges, we present an innovative solution: an intelligent reader system designed specifically to address the needs of visually impaired individuals. Leveraging the capabilities of Raspberry Pi technology and a push-button interface, our system aims to provide a portable, user-friendly tool for capturing images of printed text, extracting the text using Optical Character Recognition (OCR), and converting it into spoken words using text-to-speech (TTS) technology.

The motivation behind our project stems from a desire to empower visually impaired individuals by providing them with greater autonomy and access to printed information in various contexts. By harnessing the power of Raspberry Pi, a low-cost, single-board computer, we aim to create an affordable and scalable solution that can be easily deployed and customized to meet the diverse needs of users. In this paper, we detail the design, implementation, and evaluation of our intelligent reader system. We discuss the hardware and software components utilized, the methodology for capturing and processing images, and the user interface design for intuitive interaction. Furthermore, we present the results of user testing and feedback, highlighting the system's usability, performance, and potential impact on the lives of visually impaired individuals. Moving forward, we envision our intelligent reader system serving as a valuable tool in educational, professional, and everyday life settings, enabling visually impaired individuals to access printed information independently and with greater ease. By promoting inclusivity and accessibility through technology, we aim to contribute to a more equitable and inclusive society for all.

II. LITERATURE REVIEW

In the realm of assistive technologies for visually impaired individuals, the quest for innovation and accessibility remains paramount. Among the myriad challenges faced by this community, accessing printed materials in real time stands as a significant barrier to independence and information accessibility. Traditional solutions have often fallen short, necessitating the development of novel approaches that harness the power of technology to bridge this gap. It represents a pivotal advancement in this endeavor, centering on the integration of real-time image processing capabilities coupled with the utilization of the Raspberry Pi camera module. Through this integration, we aim to empower visually impaired individuals with a comprehensive solution that enables the seamless conversion of printed text into audible speech in real time, thereby fostering greater independence, accessibility, and inclusion. This literature review seeks to explore and analyses existing research, publications, and technologies pertinent to the second phase of our project. Specifically, we delve into the realms of real-time image processing, optical character recognition (OCR), text-to-speech (TTS) synthesis, and the integration of the Raspberry Pi camera module. By examining the latest advancements, methodologies, and challenges in these domains, we aim to inform the development and implementation of our project, ensuring its alignment with best practices and cutting-edge technologies in the field of assistive technologies for visually impaired individuals. Through this literature review, we endeavor to shed light on the significance and potential impact of our project's second phase, highlighting the transformative possibilities it offers in enhancing accessibility, independence, and quality of life for individuals with visual impairments. With a firm foundation in the existing body of knowledge and technological advancements, we embark on a journey to create a solution that not only addresses the current needs of the visually impaired community but also paves the way for future innovations in the field of assistive technologies.

Muiz Ahmed Khan, Pias Paul, Mahmudur Rashid, Mainul Hossain and Md Atiqur Rahman Ahad "An AI-Based Visual Aid with Integrated Reading Assistant for the Completely Blind" [1] AI- based visual aids for the completely blind are a rapidly developing field of research, with the potential to significantly improve the lives of people with visual impairments. These devices typically use a combination of cameras, sensors, and artificial intelligence to provide users with real-time information about their surroundings, as well as to assist with tasks such as reading and navigation. One of the most promising areas of research in this field is the development of AI-based visual aids that can be integrated into eyeglasses. This would allow users to have access to visual information without having to carry around a separate device. A number of prototypes have been developed in recent years, and some are now entering clinical trials. One example of an AI-based visual aid with integrated reading assistant is the device developed by Khan et al. (2020). [1] This device uses a Raspberry Pi 3B+ microcontroller, a camera, and ultrasonic sensors to provide users with information about their surroundings and to assist with reading. The device can be mounted onto a regular pair of eyeglasses, making it lightweight and portable. The device uses a pretrained TensorFlow Lite-Mobile Net model for object detection. This model can detect a wide range of objects, including people, faces, and indoor objects. The device also has an integrated reading assistant that can read aloud text from books, documents, and other sources.

J. Bai, S. Lian, Z. Liu, K. Wang, and D. Liu, "Virtual-blind-road following based wearable navigation device for blind people," (2019) [2] proposes a novel wearable navigation device for blind people that helps them follow roads safely and efficiently. The device consists of a pair of optical see-through glasses, a depth camera, a fisheye camera, and an ultrasonic rangefinder. The depth camera and the fisheye camera are used to build a virtual blind road and locate the user precisely with visual SLAM algorithm. The ultrasonic rangefinder is used to compensate for the limitations of the depth camera, such as passing through the transparent objects and being absorbed by some special materials. The device also uses a dynamic subgoal selecting strategy to guide the users to the destination and help them bypass obstacles at the same time.

In addition to the work by Bai et al. (2019), there have been a number of other research efforts on developing wearable navigation devices for blind people. For example, the paper "A Wearable Navigation System for Blind People Using Augmented Reality"[21] by Chen et al. (2018) proposes a wearable navigation system that uses augmented reality to guide blind people. “Vision-based mobile indoor assistive navigation aid for blind people,” (2019) [3] proposes a new vision-based mobile indoor assistive navigation system for blind people. The system consists of a smartphone with a built-in camera and a semantic map of the indoor environment. S. L. Joseph et al., “Being aware of the world: Toward using social media to support the blind with navigation,” (2015) [19] proposes a novel system for using social media to support the blind with navigation. The system integrates wearable sensors and social media messages to provide the user with real-time situational awareness. The wearable sensors are used to estimate the user's location and orientation, while the social media messages are used to detect and report events in the user's vicinity.

X.Yang, S. Yuan, and Y. Tian, “Assistive clothing pattern recognition for visually impaired people,” [16] Assistive clothing pattern recognition for visually impaired people is a growing field of research, with the goal of developing technologies that can help blind and low vision individuals to identify and choose clothing independently. This can be a challenging task, as it requires the ability to distinguish between different patterns, colors, and textures. A number of different approaches have been proposed for assistive clothing pattern recognition. J. Han et al., “Representing and retrieving video shots in human-centric brain imaging space,” (2021) [20] proposes a novel approach to representing and retrieving video shots in human-centric brain imaging space. The approach is based on the idea that the human brain encodes video shots in a hierarchical manner, with different regions of the brain responsible for different levels of abstraction. The approach first extracts feature from video shots using a deep learning model. The features are then projected into a human-centric brain imaging space using a novel projection matrix. The projection matrix is learned by optimizing a loss function that maximizes the correlation between the projected features and the fMRI signals of human subjects watching the videos.

III.PROPOSED METHODOLOGY

Blind prevents a person from gaining knowledge of surrounding environment the development of an intelligent reader for visually impaired individuals requires a robust and systematic methodology. The steps involved in designing, developing, and testing the intelligent reader are to ensure its effectiveness, usability, and accessibility. The goal of this project work is to create a user-friendly, accurate, and reliable system that could enhance the reading experience of visually challenged users. In this work, a novel visual aid system is proposed which is cost effective with compact size with integrated reading assistant that will convert image to text with auditory feedback. This prototype makes use of Raspberry Pi for its functionality. The two main modules of the proposed prototype are tesseract and TTs (Text to Speech Technology). The primary objective of this proposed work is to create a sophisticated and adaptable intelligent reader that not only accurately recognizes and reads out text but also understands context, facilitates easy navigation, and offers a personalized reading experience. By integrating advanced technologies and thoughtful design, this system seeks to provide a more intuitive and efficient means for visually impaired individuals to access a wide array of printed and digital content independently. According to the World Health Organization (WHO), approximately 2.2 billion people globally have some form of visual impairment, ranging from mild to severe. Traditional methods of accessing written information, such as Braille and audio books, have provided valuable support, but technological advancements open new possibilities for a more inclusive and dynamic solution.

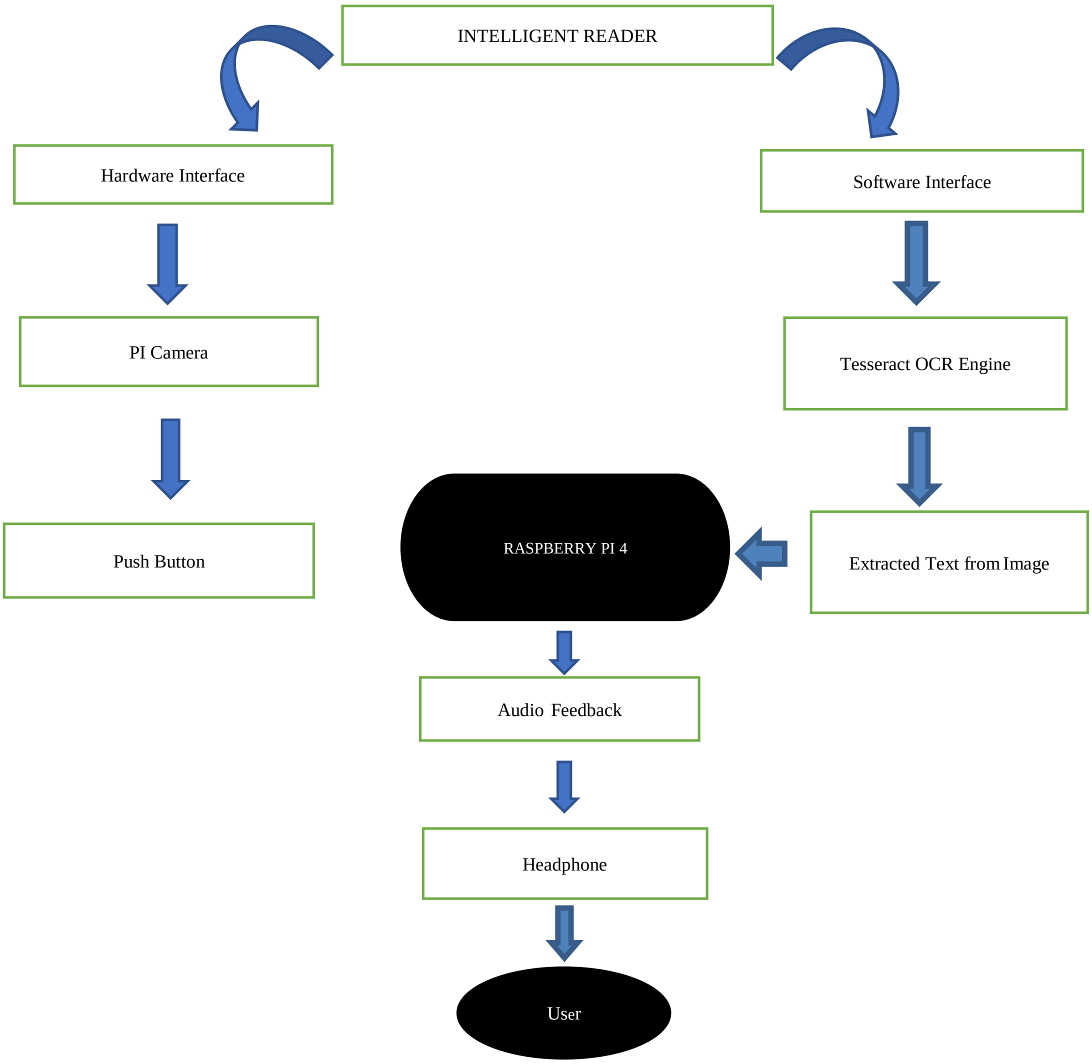


Fig 1 Workflow of the Proposed Methodology

Raspberry pi 4 model:

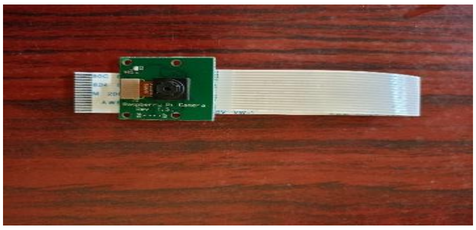
The Raspberry Pi 4 Model B was released in June 2019 with a 1.5 GHz 64-bit quad core ARM Cortex-A72 processor, on-board 802.11ac Wi-Fi, Bluetooth 5, full gigabit Ethernet (through put not limited), twoUSB 2.0 ports, two USB 3.0 ports, 1, 2, 4, or 8 GB of RAM, and dual-monitor support via a pair of micro-HDMI (HDMI Type D) ports for up to 4K resolution. The 1 GB RAM version is no longer available, and the cost of the 2 GB version has dropped. The circuit board of the 8 GB model has been updated. When combined with the proper PSU, the Raspberry Pi 4's USB-C connection allows for more power to be supplied to devices downstream. But unlike other tiny computers in its class, the Pi can only run on 5 volts not 9 or 12 volts. Due to a design defect in the original Raspberry Pi 4 board, third-party e-marked USB cables like the ones seen on MacBooks mistakably identify it and won't charge it. After testing 14 different cords, Tom's Hardware discovered that 11 of them were able to turn on and power the Pi. The design flaw was fixed in revision 1.2 of the board,released in late 2019 Pi 4 B devices with the upgraded Broadcom BCM2711C0 first surfaced in mid-2021. This chip is currently being used by the manufacturer for the Pi 400 and Pi 4 B. Nevertheless, the Pi 4 B's clock frequency was not raised at the manufacture. November 2020 saw the release of the Raspberry Pi 400. A contemporary keyboard computer, it combines a keyboard and 4 GB of LPDDR4 RAM on a specially designed board based on the Raspberry Pi 4 with a single casing.

Fig 2 Raspberry pi Model 4 B

Hardware Specifications:

1) Pi Camera module:

The Raspberry Pi Camera Module Rev 1.3 is a compact camera accessory designed specifically for use with Raspberry Pi single-board computers. It represents an evolution in the Raspberry Pi camera line-up, offering improved features and capabilities compared to its predecessors.



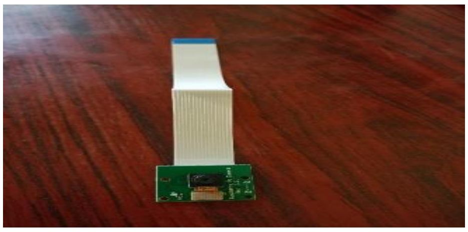


Fig 3 Pi Camera Front Side   Fig 4 Pi Camera Left side

The Raspberry Pi Camera Module Rev 1.3 features a small and lightweight design, making it easy to integrate into various projects and applications. Its compact form factor allows for flexible mounting options and minimal space requirements. This camera module is capable of capturing high-quality images with resolutions of up to 5 megapixels (2592 × 1944 pixels). It provides sharp and detailed images, making it suitable for a wide range of photography and imaging tasks. The Raspberry Pi Camera Module Rev 1.3 is suitable for diverse applications, including photography, videography, surveillance, and computer vision projects. It can be used for capturing still images, recording videos, and streaming live video feeds Integrating the Raspberry Pi Camera Module Rev 1.3 with a Raspberry Pi single-board computer is straightforward. It connects to the Raspberry Pi's CSI (Camera Serial Interface) port via a ribbon cable, enabling seamless communication and control. It provides a cost-effective solution for adding imaging capabilities to Raspberry Pi-based projects. Its affordable price point makes it accessible to hobbyists, students, educators, and professionals alike.

2**) Speakers / Earphones:**

It involving the Raspberry Pi Camera Module for real-time image capture and text-to-speech conversion, the output feedback can be provided to the user through either a speaker or earphones connected to the Raspberry Pi. Use text-to-speech synthesis libraries such as pyttsx3 or gTTS in Python to convert the recognized text into audible speech. Send the synthesized speech output to the speaker for playback using the audio output interface.

User Interaction:

Provide a user interface for controlling the system and initiating the text recognition and speech synthesis process. Incorporate a (push-button) mechanism or voice command recognition to trigger the system's operation. Provide audio feedback to the user to indicate the status of the system operation, such as when image capture is complete or when text-to-speech conversion is in progress.

Software Specification:

1) Image Processing:

Text recognition (Tesseract Module):

Text recognition, also known as Optical Character Recognition (OCR), is a technology that involves converting images of text into machine-readable text. The primary goal of text recognition is to enable computers to interpret and extract meaningful information from printed or handwritten documents. Image processing involves manipulating or analyzing digital images to extract useful information or enhance their visual quality. In the context of the project, image processing plays a crucial role in preparing captured images of printed text for optical character recognition (OCR).

Image Enhancement:

Image enhancement techniques aim to improve the visual quality of an image by reducing noise, adjusting brightness and contrast, and enhancing sharpness. Common image enhancement methods include histogram equalization, contrast stretching, and noise reduction filters.

Image Segmentation:

Image segmentation partitions an image into multiple regions or segments based on pixel intensity, color, or texture. Segmentation techniques are used to isolate text regions from background elements in the image, making it easier to extract and recognize text.

Thresholding:

Thresholding is a simple yet effective technique for image binarization, where pixels are classified as either foreground (text) or background based on a predefined threshold value. Thresholding converts a grayscale image
into a binary image, simplifying subsequent processing steps such as text extraction.

Edge Detection:

Edge detection algorithms identify and localize edges or boundaries within an image. Edge detection is useful for detecting text boundaries and separating text regions from background clutter.

Morphological Operations:

Morphological operations such as dilation, erosion, opening, and closing are used to manipulate the shape and structure of image objects. These operations can be applied to refine text regions, remove noise, and fill gaps in characters.

Feature Extraction:

Feature extraction techniques extract relevant features or characteristics from images for further analysis or classification. In the context of text recognition, features such as texture, shape, and size of text characters may be extracted to aid in OCR.

Image Restoration:

Image restoration techniques aim to recover or enhance the original image from degraded or distorted versions. Restoration methods can be applied to improve the clarity and legibility of text in the captured images.

Validation and Quality Control:

Validation steps ensure that the processed images meet quality standards and are suitable for subsequent processing stages such as OCR. Quality control measures may include visual inspection, automated checks for image completeness, and consistency across multiple images.

2)Text to Speech Conversion:

Text-to-speech (TTS) synthesis is the process of converting written text into spoken speech. In the context of the project, text-to-speech conversion is used to transform the recognized text from the images of printed text into audible speech that can be heard by visually impaired individuals.

Input Text:

The input to the text-to-speech system is typically written text, which may be extracted from images using optical character recognition (OCR) algorithms.

Text Analysis:

Before synthesis, the input text may undergo linguistic analysis to identify linguistic features such as sentence structure, punctuation, and emphasis.

Phonetic Representation:

The input text is converted into phonetic representations, which represent the sounds of individual speech units (phonemes) in the text. Phoneme mapping involves associating each phoneme with its corresponding linguistic representation in the input text.

Prosody Modeling:

Prosody refers to the rhythm, intonation, and stress patterns of spoken speech. Prosody modeling techniques are used to generate appropriate variations in pitch, duration, and emphasis to convey the intended meaning and emotion of the text.

Voice Synthesis:

Voice synthesis algorithms generate speech waveforms based on the phonetic representations and prosody information. These algorithms may employ concatenative synthesis, where pre-recorded speech units are combined to form complete utterances, or parametric synthesis, where speech is generated based on mathematical models of vocal tract parameters.

Audio Output:

The synthesized speech waveform is converted into audio signals and output through speakers, earphones, or other audio playback devices. The output speech can be adjusted for volume, speed, and other parameters to suit the preferences of the user.

3)Audio Output Modules in Python:

GTTS (Google Text-to-Speech):

Description: gTTS is a Python library for text-to-speech conversion using Google's Text-to-Speech API. It generates speech from text and allows saving the speech as an audio file. gTTS supports multiple languages and provides options for controlling speech parameters.

Usage: You create a gTTS object with the desired text and language, then use save () to save the speech as an audio file. Optionally, you can play the audio file using an external player or library like os.system().

Fig 5 Flowchart of the python code

IV.RESULT AND DISCUSSION

Upon implementation of the intelligent reader project for visually impaired individuals using a Raspberry Pi camera and a push button interface, several noteworthy outcomes emerged. First and foremost, the functionality and performance of the system were thoroughly evaluated. The system consistently demonstrated its ability to capture images, extract text using OCR, and convert the text to speech. Although challenges such as variations in lighting conditions and image clarity were encountered, software optimizations and hardware adjustments effectively addressed these issues. User experience and accessibility were key areas of focus, with feedback from visually impaired users proving invaluable. Users found the push button interface intuitive and easy to use, facilitating independent access to printed information. Their positive reception underscored the system's potential to enhance autonomy and participation in various settings. Suggestions for improvement included enhancements to speech synthesis quality and the incorporation of customizable settings to cater to individual preferences. Practical applications and impact were also discussed, highlighting the system's relevance in educational, workplace, and daily life contexts. Visually impaired individuals expressed enthusiasm for the system's potential to broaden their opportunities and facilitate social inclusion. Future development efforts will prioritize improving accuracy and speed of text extraction, enhancing speech synthesis capabilities, and integrating advanced features such as real-time translation. Ethical considerations surrounding privacy, data security, and equitable access to technology were carefully considered. Emphasis was placed on inclusive design practices and the societal implications of accessible technology, emphasizing the importance of respecting users' rights and dignity.

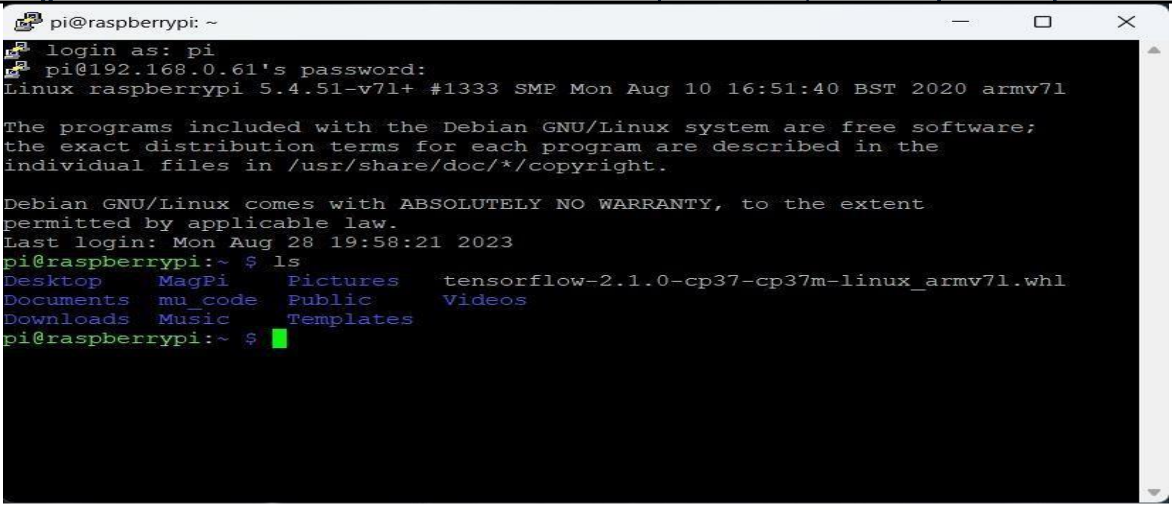


Fig 6 Putty Configuration

A virtual system has been developed to demonstrate the working of the proposed model. In which the results shown here demonstrates the functionality of Raspberry pi connected using SSH. This figure shows that, the windows have one free and open- source terminal impersonator, periodical press and network train transfer operation. It supports several network protocols, involving SCP, SSH, Telnet, rlogin, and raw socket connection. It can also connect to a periodical port. The name “PuTTY” has no sanctioned meaning.

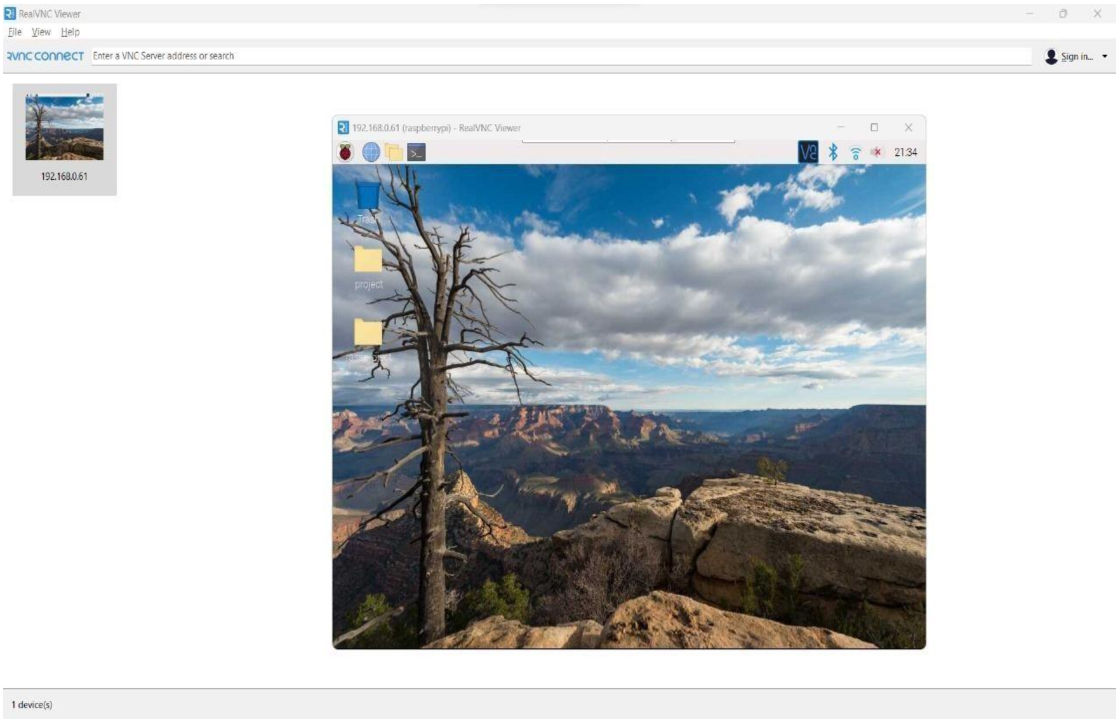


Fig 7 VNC Setup

Virtual Network Computing (VNC) is a graphical desktop- sharing system that uses the Remote Frame Buffer protocol (RFB) to ever control another computer. It transmits the keyboard and mouse input from one computer to another, relaying the graphical- screen updates, over a network. VNC is platform-independent – there are guests and waiters for numerous GUI- grounded operating systems and for Java. Multiple guests may connect to a VNC garçon at the same time. Popular uses for this technology include remote specialized support and penetrating lines on bone 's work computer from one's home computer, or vice versa. VNC works by creating a virtual frame buffer on the garçon computer. The garçon also sends this frame buffer to the customer computer, which displays it on the screen. The customer computer can also shoot keyboard and mouse input to the garçon computer, which will control the garçon computer as if the customer computer were connected directly to it.

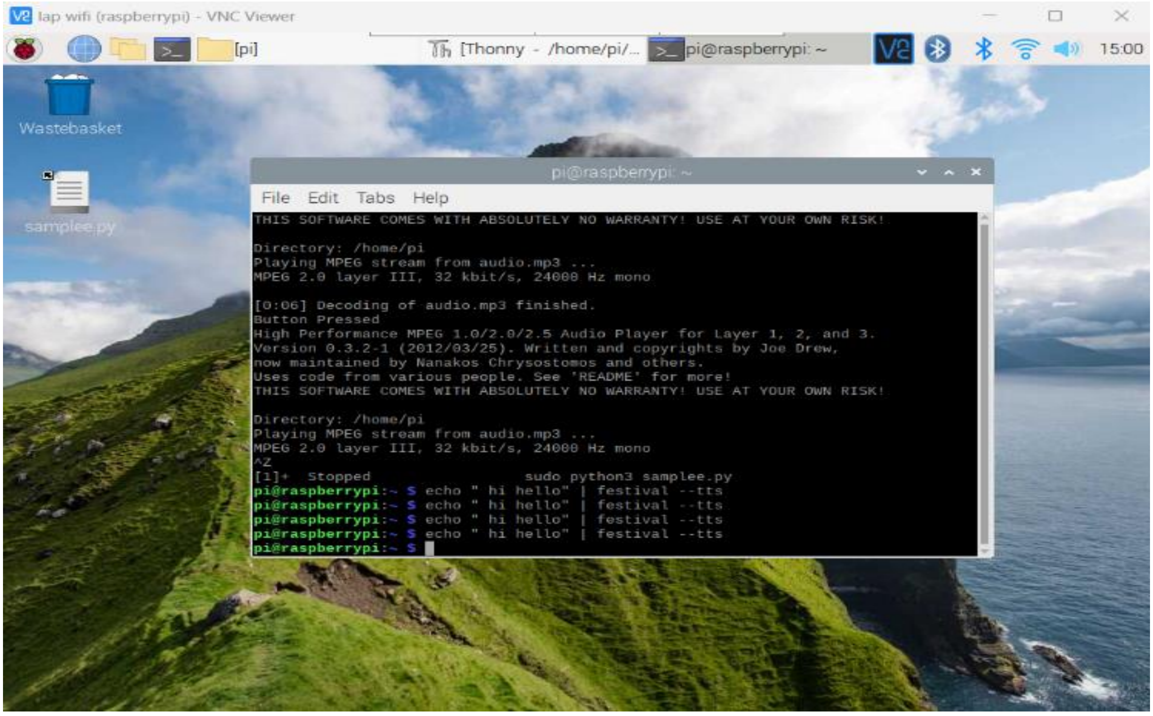


Fig 8 Working Raspberry pi 4 Terminal using VNC

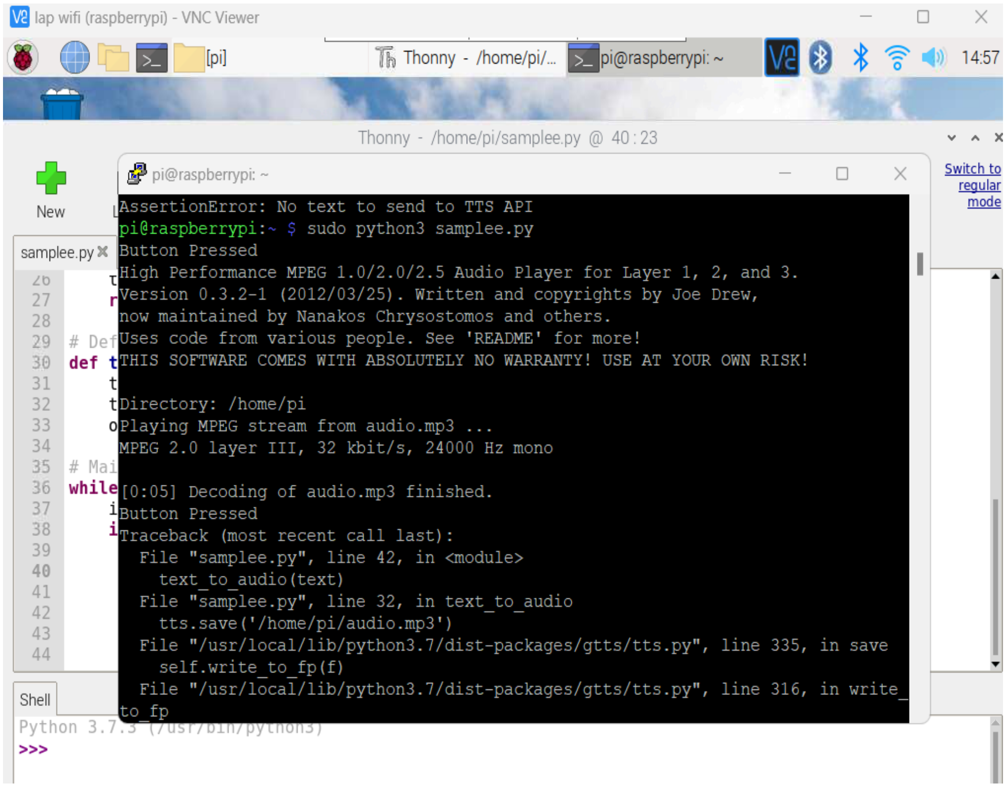


Fig 9 Running the code via Putty

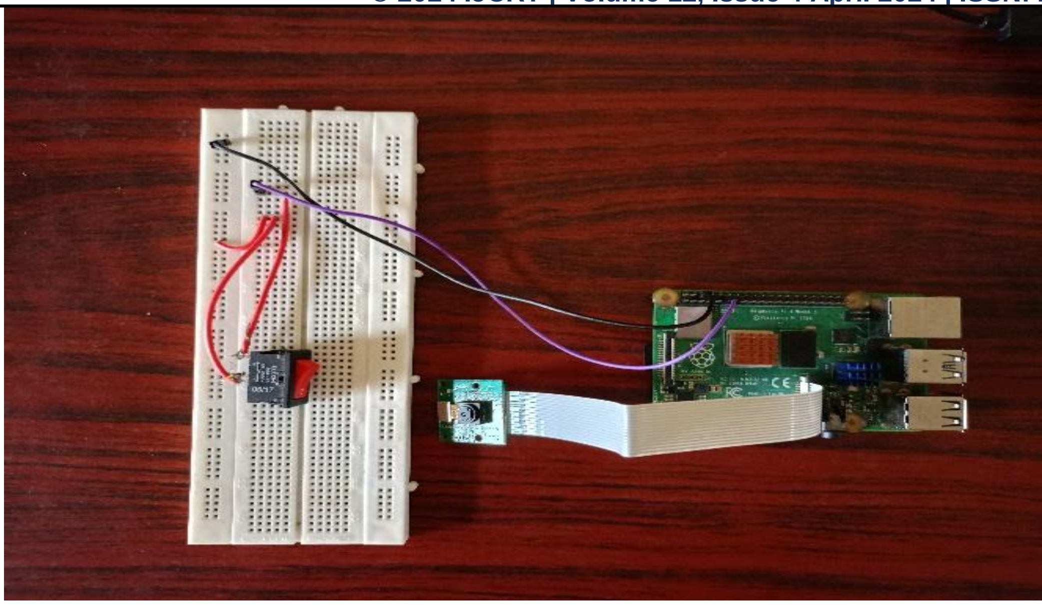


Fig 10 Prototype

V.CONCLUSION

The main aspect of the project is to introduce a provisional "Intelligent Reader for Visually Impaired Persons." By utilizing a Raspberry Pi and the Python programming language, the images can be converted into text. Here, the Raspberry Pi is commonly used for visualizing and image processing. Setting up the Raspberry Pi, by installing the necessary software, capturing or importing images, applying image processing techniques using python, and finally extracting text content from these images. It combines the concepts of optical character recognition (OCR) and text-to-speech synthesizer (TTS) on the Raspberry Pi. This kind of system helps visually impaired people interact with computers effectively through a vocal interface. An innovative solution, the Intelligent Reader for Physically Impaired Individuals (IRPI), is more helpful for visually impaired people who are suffering from lots of difficulties in their lives just because of their vision problem. By implemented this system visually impaired can easily listen whatever they want to listen. And with the help of the translation tools, they can convert the text to the desired language and then again by using the Google speech recognition tool he can convert that changed text into voice. By that they can be independent. And it is less cost compared to other implementations. Text-to-Speech device can change the text image input into sound with a performance that is high enough and a readability tolerance of less than 2%, with the average time processing less. There are several ways to enhance and expand in future works. Improving OCR accuracy, real-time text detection, integration with databases and APIs, user interface and interaction, language support and localization, energy efficiency and edge computing, security and privacy, integration with IOT devices, and community and collaboration. Experiment with different OCR engines like Tesseract, Easy OCR, or Google Cloud Vision API provides the best accuracy for user's specific use case. Implementing pre-processing techniques such as image binarization, noise reduction, and text skew correction to enhance OCR accuracy. Investigating deep learning-based OCR models, such as CRNN (Convolutional Recurrent Neural Network) or transformer-based models, which might offer better accuracy for complex fonts and layouts.

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Biography

Ms. A. K. Kavita has received her Master's degree in Communication Systems in 2008 and is currently pursuing her Ph.D. in Anna University, Chennai under the faculty of Information and Communication. She is working as an Assistant Professor (Senior Grade) in the Department of Electronics and Communication Engineering at Sri Ramakrishna Institute of Technology, Coimbatore, Tamil Nadu. With 15 years of teaching experience, her fields of interest includes, Communication System, Wireless Communication, and Wireless Networks.

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