Wearable Reading Wrist Device for Visually Impaired People

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Abstract- Visually impaired people occasionally experience difficulty accessing written materials. Blind persons are currently assisted in reading by the Braille system, which is a code system in which dots represent alphabetic letters. There are only so many books that a visually impaired person can read because not all books are published in Braille. Thus, it is imperative to build a reading device that makes eyes-free operation (reading) more manageable. The current work proposes a wearable reader that captures on-the-spot images of printed text from a book using a tiny, high-resolution camera. The printed text graphics are converted to a digital representation of the text using a Raspberry Pi microcontroller.. If the user strays from the current text line, the device's built-in vibration motors will assist in helping them orient themselves toward the direction of reading. The text on the computer sounds like speech to the user. With the help of this finger-worn gadget, blind or visually impaired people can access a wide range of educational resources for their further education.

Keyword - Miniaturized Camera, Image Processing, Raspberry Pi, Vibration Motors

1. INTRODUCTION

The World Health Organization estimates that at least 2.2 billion people are blind globally, of whom at least 1 billion have preventable or treatable visual impairments. An estimated 65.2 million individuals are believed to have cataracts, while slightly over 123.7 million people have untreated refractive error.Presbyopia affects 826 million people, retinopathy affects 3 million, trachoma affects 2 million, glaucoma affects 6.9 million, and ocular opacities affect 4.2 million. The billion people consist of these people as well as others with moderate to severe distance vision. Normal Vision vs. Moderate Vision Impairment Blindness and Severe visual Impairment are the four categories of visual function [3]. Blindness is the state of not being able to see visual stimuli due to neurological or physiological issues.

A complete lack of ability to perceive visual light is known as total blindness, while partial blindness is caused by a lack of integration in the optic nerve or visual center of the eye's growth [4].

Braille books are the only source of information for people who are visually impaired (VI), but they are very rare and difficult to use. In addition, employing Braille A complete lack of ability to perceive visual light is known as total blindness, while partial blindness is caused by a lack of integration in the optic nerve or visual center of the eye's growth [4].

Braille books are the only source of information for people who are visually impaired (VI), but they are very rare and difficult to use. It's challenging to read books, which makes assistive technology more necessary. With an assistance technology, the blind could pursue higher education and read any book. Assistive devices for the blind are widely available, albeit not all are available for text access. A 2018 poll found that slow or erroneous processing is often the reason for the underutilization of easily accessible technologies, such as eBook readers, desktop scanners, screen readers, and smartphone applications. One drawback of the Braille system was that it required learning the Braille alphabets in order to be used, which prevented blind people from accessing and reading books until much later. Readability of Braille text is frequently viewed as difficult when individuals are rushing. Because of their weight and linked components, the original electronic readers were less portable and more challenging to operate. Wearable is exactly how to describe the latest reading systems.

Character recognition is a large category that includes almost all techniques of character recognition.In [9] This field is expanding these days and is used for things like language understanding, item identification, and lost or missing data restoration. Reading gadgets of days frequently use optical character recognition (OCR) technology [10]. Seeing and classifying objects is one of the ways we use our visual recognition senses, such as our eyes. Handwritten and printed text can be converted into editable text using a method known as optical character recognition [11]. TTS systems and OCR are used together to read printed text on paper [12]. It was tough to read because of this process since it was hard for the user to position the image appropriately.

It is therefore necessary to have an assistive wearable reader—one that can scan an image of printed text from a book and assist the user in aligning himself with a particular line to read. The suggested work develops an intelligent, finger-worn reading device that is simple to use and helps blind people read. This project intensively converts text to speech using a raspberry pi and a text-to-speech converter. Additionally, haptic feedback is used to assist the user in aligning with the text.

2. LITERATURE SURVEY

1) Title: Raspberry Pi Based Wearable Reader For Visually Impaired People with Haptic Feedback

Authors: S. Srija, P. Kawya, T. Akshara Reddy, M. Dhanalakshmi

Summary: Accessing printed text is a common challenge for individuals with visual impairments. Nowadays, the Braille system—a dot-based code scheme that represents letters in an alphabet—is used to help blind people read. A person with visual impairments can only read a certain amount of books because not all books are written in braille. The creation of a reading gadget that facilitates more controllable eyes-free operation (reading) is therefore necessary. In this study, a wearable reader with a high-resolution tiny camera is proposed to take photographs of printed text from a book in real time. An Arduino Pi microcontroller is used to process the printed text pictures and create a digitized version of the text When a user deviates from the current text line, the device's integrated vibration motors help them orient themselves in the direction they are reading. A voice can be heard by the user from the electronic text. Blind persons can utilize this gadget, which they can wear on their fingers, to access a multitude of learning resources for their academic pursuits for their research ,blind persons.

Applications:

1.Text Reading and Recognition: By converting written text from books, signs, labels, or menus into tactile input, the technology allows users to "read" without using their eyes.

2. Object Recognition: It can recognize obstacles or items in the user's path and send haptic cues to warn them of their surroundings and avoid collisions.

3. Education Support: Helping pupils by giving them instant access to printed resources in libraries, schools, and testing environments.

Advantages:

1. Affordability: The Raspberry Pi is more accessible due to the comparatively low cost of its components.

2. Customizability: Users can modify the gadget to fit their own requirements or inclinations.

3. Open-Source Community: Availability of a large developer community and resources for updates and assistance. 4. Portability: As a wearable, it provides customers with convenience and mobility when they're on the go.

5. Haptic Feedback: By providing a non-visual mode of information delivery, tactile experiences improve accessibility. 6. Versatility: Able to carry out a variety of tasks, including object and text recognition.

2) Title: PISEE: RASPBERRY PI-BASED IMAGE TO SPEECH SYSTEM FOR THE VISUALLY IMPAIRED WITH BLUR DETECTION

Authors: Sanjay Dutta, Sonu Dutta, Om Gupta, Shraddha Lone, Prof. Suvarna Phule

Summary: When it comes to helping visually impaired people navigate their environment more efficiently, image to voice conversion is a vital piece of technology. The purpose of this study is to investigate how visually impaired people can benefit from image to speech conversion plus blur detection. We provide a system that can distinguish between fuzzy images and translate images into speech. With a 5MP Raspberry Pi camera, speaker, and amplifier, the suggested setup makes use of a Raspberry Pi 3 B. Software is developed using the Python programming language in conjunction with the subprocess, Pytesseract, OpenCV, and NumPy libraries. After taking a picture, the algorithm determines whether it is blurry. The system reads out the text it has recognized from the image if it is blurry, and declares the same if it is not. Multiple photos have been used to successfully test the system, and the entire procedure takes no more than 30 seconds. The suggested method has a great deal of promise for future development and can greatly enhance the quality of life for those who are blind or visually impaired.

Applications :

1.Daily Living chores: Assisting with routine chores such as reading prescription labels, differentiating clothes, and locating goods in the kitchen.

2. Public Transportation: Helping with the identification of bus numbers, train timetables, or station details for self-directed travel.

3. Environmental Information: supplying data on the surrounding environment, including temperature, light intensity, and object proximity.

4. Remote Assistance: Linking visually impaired people to extra help or support via remote assistance through integration with other devices or services.

5. Training and Rehabilitation: Offering direction and movement feedback while helping with mobility training or rehabilitation exercises.

3) Title: Haptic Feedback Wristband for Tactile Graphics Reader

Authors: Muhammad Ikmal Hakim Shamsul Bahrin, Nabilah Atiqah Khairul Anuar, Hazlina Md Yusof, Shahrul Na'im Sidek, Aimi Shazwani Ghazali,Siti Suhaila Burihan, Abdul Ghaffar Abdul Rahman and Muspirah Ahmad Salim

Summary: Blind and visually impaired (BVI) readers have historically had difficulty deciphering tactile graphics since doing so requires specific knowledge, instruction, and frequently outside help. Other drawbacks of current audio feedback systems include exposure to ambient noise and vague recommendations. Consequently, the design of a haptic feedback system-based assistive device for tactile graphics reading is presented in this work. This gadget looks like a digital watch and has an adjustable band so it can fit on a range of wrist sizes. When a user explores the content of a tactile image, four strategically positioned mini-motor discs provide vibration signals to their hand. To test this haptic feedback wristband's efficacy, sighted readers who were blinded participated in a pilot study. The test results showed that participants could successfully identify different vibration intensities and direction indications. Notably, the success rates for vibration intensity detection and navigation also surpassed 70% and 85%, respectively.

3. PROPOSED SYSTEM

3.1 Materials Used:

1. Hardware components

i . Raspberry Pi Microcontroller Board

The RP2040 microcontroller chip, created internally by Raspberry Pi, is the centerpiece of the low-cost, high-performance Raspberry Pi Pico microcontroller board. Operating at 133MHz, this chip has two ARM Cortex-M0+ processors, 264k SRAM, and 2M on-board QSPI storage. The majority of the microcontroller pins on the Pico board are brought to the user IO pins on the board's edges, requiring little additional circuitry to accommodate the RP2040 processor. The on-board Switched Mode Power Supply (SMPS), an LED, and system voltage sensing are only a few of the internal tasks that four RP2040 IO pins are utilized for.

A flexible option for developers wishing to work with microcontrollers, the RP2040 microcontroller supports MicroPython as well as C/C++. In cases where a Raspberry Pi's power is not needed for simpler projects, it's a great substitute for Arduino in cases where using the Arduino platform is not preferred.

Figure: Raspberry Pi Microcontroller Board

ii. Raspberry Pi Camera

Designed to deliver excellent sensitivity, minimal crosstalk, and low noise picture capture in an ultra-small and lightweight design, the Raspberry Pi Camera Module is a high-definition camera compatible with all Raspberry Pi models. The CSI (Camera Serial Interface) connector, which is intended just for camera interface, is used to link it to the Raspberry Pi board. Pixel data is the only thing that the CSI bus can transport to the processor at incredibly fast data speeds.

The camera module is a fixed-focus module that employs a Sony IMX 219 PQ CMOS image sensor. 3280 x 2464 pixels can be captured in still images with an 8-megapixel resolution. Maximum image transfer rates are 720p at 60 frames per second and 1080p at 30 frames per second (encode and decode). The specialized 15-pin MIPI Camera Serial Interface (CSI-2) is connected to the Raspberry Pi via a 15-pin ribbon wire.

In addition to automatic band filtering, automatic exposure control, automatic white balance, automatic luminance detection at 50/60 Hz, and automatic black level calibration are all included in the camera module. With measurements of 23.86 x 25 x 9 mm and a weight of 3g, it functions within a temperature range of -20º to 60º for stable images.

Figure: Raspberry Pi Camera

iii. Cellular Communication and GPS Modules

GPS modules with cellular communication can greatly expand a Raspberry Pi's capabilities, allowing it to track its location precisely and communicate over cellular networks. With a focus on GPS modules since they are more frequently used with Raspberry Pi projects, this comprehensive guide explains how to interface both kinds of modules with a Raspberry Pi.

Interface of GPS Module with Raspberry Pi:

- Setting up the Raspberry Pi for GPS: Prior to attaching the GPS module, you must set up the operating system of the Raspberry Pi so that it can connect to the GPS receiver. This is making sure the serial ports are left on and turning off the login shell via a serial connection. Selecting "Interfacing Options" and then "Serial" in the raspi-config utility will accomplish these.
- Establishing a GPS receiver connection Through the use of the TX and RX ports, the GPS module is normally connected to the Raspberry Pi serially. Enabling the connection between the Raspberry Pi's TX output and the module's RX input is really important. Make that the module is also connected to the Raspberry Pi's power pins at the correct voltage 3.
- Software Setup: The required software must be installed after the GPS module is connected. This involves running the command sudo apt-get install gpsd gpsd-clients to install both gpsd and gpsd-clients. To access the serial port and control the GPS daemon (gpsd) 5, you might also need to add the pi user to the dialout group.

Cellular Communication :

An LTE shield can be used to provide 3G/4G LTE connectivity to the Raspberry Pi for projects that need cellular communication. To accomplish this, attach the LTE shield to the Raspberry Pi and install the required libraries and packages by following the setup instructions included with the shield. With this configuration, the Raspberry Pi can communicate cellular networks, without reference to Bluetooth or Wi-Fi.

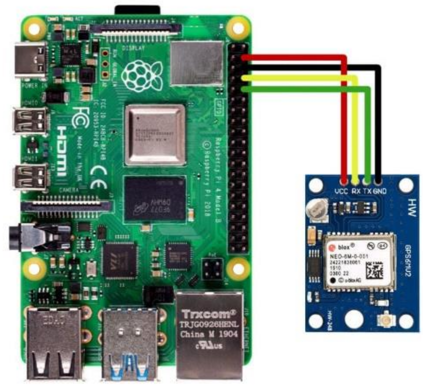

Figure: GPS Modules

iv. Buzzer and Vibration Alarm

An electrical signal can cause a buzzer, which is a basic gadget, to emit sound. Alarm systems frequently use it to notify users of certain events, such as motion detection or the opening of a door or window. A buzzer interfaced with a Raspberry Pi can be programmed to sound an alert in response to particular inputs or conditions.

2. Software Components

i. Python Language

Python is a popular high-level programming language that is easy to learn and understand, making it a great option for both novice and seasoned programmers. Numerous industries, including web development, data analysis, artificial intelligence, and more, heavily rely on it.

- Simple to Learn: Compared to other programming languages, Python is simpler to learn due to its easily legible and uncomplicated syntax. Beginners can rapidly pick up the language thanks to its emphasis on readability and simplicity.
- Object-Oriented Programming: Python facilitates the creation of classes and objects through object-oriented programming. One of Python's most powerful features is this feature, which makes it possible to create intricate applications.
- Extension: Python's functionality may be readily expanded by adding new C or C++ functions and data types. This makes it appropriate for a broad range of uses, including scientific computing and web development.
- Interpreted Language: Python is an interpreted language, meaning that commands are carried out line by line. Python is a great option for scripting and quick application development because of this capability, which enables interactive writing and debugging.

Figure : Python Language

3.2 Methodology:

The core features of the prototype include taking pictures with an OCR-based Raspberry Pi module, processing those photos to produce text, speaking text out using Google Text to Speech (gTTS), and giving haptic feedback to assist with in-text line orientation. The block diagram in Fig. 1 illustrates the method. Written text is identified from images captured using a Raspberry Pi camera and microcontroller. The Rasbian operating system was used to send commands to the Raspberry Pi microcontroller via Python.

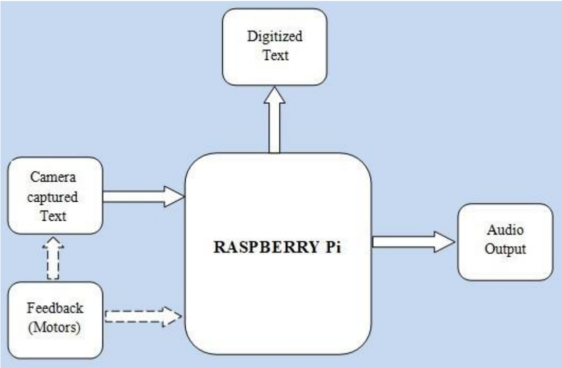

Fig 1 : Raspberry PI based OCR system

1. Acquiring printed text as image: A high-resolution Rasberry pi tiny camera was used to capture the images from the book. For the required tasks, Python packages might be utilized. In this device, the packages that have been implemented are the gTTS, OpenCV, PIL, time, and Pi camera by Tesseract. Using the Pi camera module to take images and the time module to establish the interval, the Raspberry Pi camera was ready to record. To continuously evaluate and modify images, two programming function libraries are used: Open Source Computer Vision (Open CV) and Python Imaging Library (PIL). This leads to the recording of a sequence of images accompanied by text. By converting the printed text into digital text, one of the Python modules named Pytesseract is utilized to extract the word string. Next, we read the computerized text aloud using the Google Text to Speech (gTTS) converter (covered in earlier parts).

2. Conversion of printed text to computerized text and Extraction of words

Taken using the Raspberry Pi camera, these images are raw. The camera was configured to fixate on catching words, rather than reading multiple words at once. Pre-processing (i) and thresholding (ii) are the two fundamental steps that must be finished in order to retrieve words from printed text. The raw image's background must be eliminated as the first step in the pre-processing procedure. In order to do this, noise or unwanted pixel values are removed using the median blurring technique. A number of thresholding strategies are then applied, whereby the intensities of the neighboring pixels are used to modify the value of each pixel (as discussed in section III-B). The words in the image are then segmented using the Gaussian Adaptive thresholding technique after the Gaussian weighted average of the pixel values is computed with OpenCV[13]. To convert the image's segmented words into an electronic text, utilize the tesseract library and the image to string function.

3. Text-to-speech conversion: The Raspberry Pi can convert digital text to audio output by installing the Google Text to Speech conversion (gTTS) module and configuring the device's coding algorithm. Many modules, like Pyttsx text to voice, SAPI 5 for Windows XP, Vista, and 7, Google Text to voice, and others talk on any platform that can host share libraries, such as Fedora and Ubuntu Linux. The one used in the prototype was the Google Text to Speech Converter.

4. Haptic feedback: The wearable reader that is worn on the finger is equipped with vibrating motors that function as a haptic feedback system to continuously monitor the reading process. The device will sound a warning if the user begins reading a line above the current line and strays from the current text-line.

4. Result and Analysis

The Raspberry Pi camera captured raw images. To retrieve the required printed text from these images, thresholding is used, and pre-processing is needed to get rid of background noise. Here is a discussion of the results of preprocessing and word-extraction from printed text using thresholding.

A. Pre-processing printed text

The first and most crucial step in accurately extracting the text was to brighten the captured image. To do this, move the LED in closer proximity to the Raspberry Pi's camera. The continuous capture of photos in sufficient light cancels out the red light that typically indicates that the camera is on.

B. Thresholding techniques

The next challenge to tackle in order to identify the best word extraction technique was the thresholding process. A multitude of thresholding methods were applied, such as adaptive thresholding, gaussian thresholding, binary thresholding, and the Otsu approach[14]. A overview of the results for the perception-based Image Evaluator (PIQE) score for each thresholding approach is shown in Table I[15]. PIQE is a numerical score that runs from 0 to 100 that indicates the quality of the picture.
Image quality and PIQE score have an inverse connection. In comparison to results produced using various thresholding approaches, the table indicates that adaptive thresholding yields a PIQE score of 44.74, which is much lower. To reliably extract words from the printed text, adaptive thresholding is therefore used in the current work. The device can also discriminate between numerals and capital and small letters. The images were thresholder using the adaptive thresholding technique, and the Raspberry Pi camera continuously captured images at a rate of 32 frames per second. As shown in Fig. 5, the wearable reading device that recognizes words while a user is reading a book is fully set up.

C. Approaches on haptic feedback

A feedback system can be built using either of two techniques: pixel-level thresholding or region-based thresholding i. thresholding at the pixel level: After adaptive thresholding, the words are taken out. Before providing voice output to the visually handicapped, haptic feedback should be given to the user if there is a divergence from the text line's current position. When employing the pixel-level thresholding approach, all of the pixel values in a particular frame—after the words have been extracted—are put together as you scroll over the line. The total value of pixels varies when the user moves the device up or down. Based on the sum of the pixel values, vibration motors connected to a wearable device will begin to produce input.
ii. Region-based thresholding: Two lines, each with a size of 250 by 200 pixels, are created using the retrieved words in region-based thresholding. In order to generate haptic feedback, the word in the second line should be compared with the word that is to be read in the first. The first and second words in the text's top and bottom lines are thus cut and saved separately. Fig. 6 displays the top and bottom sections that were clipped for text reading and response. As the user presses the reading device upward, the place of the second word now overlaps with the first line. The user is thus advised to scroll down to help him get his bearings in the content.
Thus, when there is an upward departure from the current text line, the user is notified. These notifications are sent out by vibrating motors in the reading gadget.

D . Audio output

After extracting a word using region-based thresholding from the upper line text, the retrieved word is output as audio via the Google Text-to-Speech (gTTS) converter module. Hearing the speech output requires using a Bluetooth speaker that is connected to the gadget.

5. CONCLUSION

The Raspberry Pi-powered wearable reader splits images of printed text into individual text segments. Numerous thresholding strategies were employed in order to consistently extract the text; of these, the adaptive thresholding strategy is believed to perform better than the others.
A haptic feedback system with audio output was also set up based on region level thresholding to identify movement departures from the text-line, which should aid users in accurately orienting themselves while reading. Thus, with the aid of this wearable reader, the visually impaired may read printed text from any book. It is possible to reduce the size of the gadget and employ a haptic feedback system to detect deviations in all directions because the suggested solution only targets upward deviations from the current text-line.

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