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SMART GLASSES FOR VISUALLY IMPAIRED INDIVIDUALS

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ABSTRACT—

This paper presents a comprehensive overview of a smart wearable system developed for visually impaired individuals, focusing on enhancing their independence in educational and daily environments. The smart glasses integrate a range of embedded systems including Raspberry Pi, ultrasonic sensors, RFID modules, and a camera module to provide functionalities such as obstacle detection, text-to-speech conversion, and location identification. These glasses help users read printed English text by converting it into audio, identify their surroundings through RFID, and ensure a safer and more navigable experience using ultrasonic proximity detection. The system employs technologies like OCR, OpenCV, gTTS, and Google Translate API, presenting a cost-effective, portable, and practical solution for assistive technology.

Keywords: Assistive Technology, Smart Glasses, Embedded Systems, OCR, Raspberry Pi, Ultrasonic Sensor, RFID

INTRODUCTION

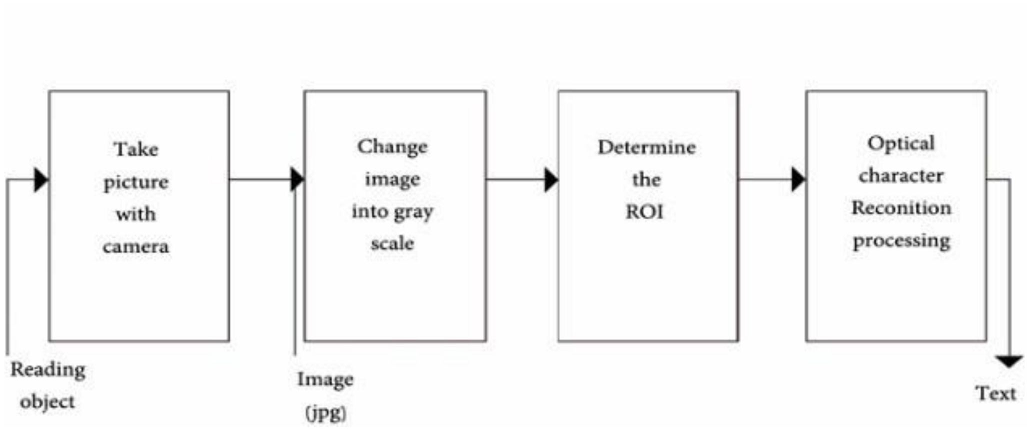
Smart glasses for visually impaired individuals represent a significant innovation in assistive technology. These glasses are equipped with embedded components and intelligent software to support blind or low-vision users in recognizing printed text, understanding their surroundings, and safely navigating through environments such as schools and universities. Using embedded systems, the solution transforms visual input into auditory feedback. The core technologies integrated into this device include text recognition using OCR and EAST detectors, object proximity detection using ultrasonic sensors, and contextual awareness using RFID tags. Through voice outputs delivered via connected headphones, the device enhances user autonomy and accessibility.

EMBEDDED SYSTEM COMPONENTS AND ARCHITECTURE

These glasses are equipped with embedded components and intelligent software to support blind or low-vision users in recognizing printed text, understanding their surroundings, and safely navigating through environments such as schools and universities. Using embedded systems, the solution transforms visual input into auditory feedback. The core technologies integrated into this device include text recognition using OCR and EAST detectors, object proximity detection using ultrasonic sensors, and contextual awareness using RFID tags. Through voice outputs delivered via connected headphones, the device enhances user autonomy and accessibility. The Raspberry Pi 3 Model B/B+ serves as the heart of the embedded system, integrating all the components and processing the inputs using Python-based scripts. It operates the OCR engine, interfaces with ultrasonic and RFID sensors, and converts detected text to voice. Ultrasonic sensors (HC-SR04) measure the distance between the user and an object to ensure a clear image is captured by the webcam, optimized between 40-150 cm for this application. The RFID reader identifies tagged locations such as classroom doors and provides voice-based identification to the user. The webcam acts as the visual sensor for capturing text-containing images, triggered via a button press and assisted by ultrasonic measurements. Headphones connected to the Raspberry Pi deliver real-time voice feedback conveying text recognition results or translated outputs.

SOFTWARE TOOLS And TECHNOLOGIES

The software suite includes Raspbian Stretch OS to support Python and OpenCV libraries. The OCR is implemented using Tesseract in combination with OpenCV's EAST text detector for accurate text detection and extraction. Google Translate API provides translation of English text into Arabic, and Google Text-to-Speech (gTTS) converts recognized or translated text into audio feedback. The system flow starts with the user pressing a button to capture text, followed by ultrasonic validation of the distance. If within the proper range, the webcam captures an image, OCR detects the text, and gTTS converts it into audio. If the translation button is pressed, Google Translate provides a translated version that is also read out loud. RFID tags help identify classrooms and halls, providing audio location information.

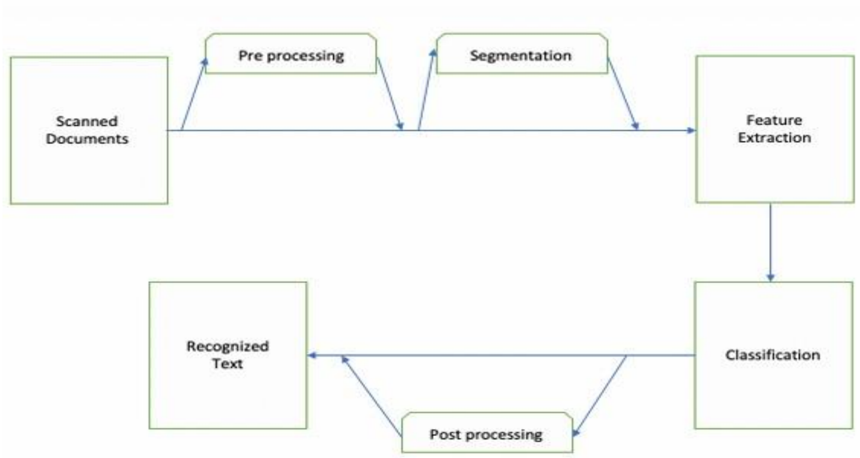


METHODOLOGY

OCR Mechanism The Optical Character Recognition (OCR) mechanism is a critical component of the smart glasses system, enabling the conversion of printed English text into audible speech. The OCR pipeline implemented in the project utilizes Tesseract OCR engine alongside OpenCV's EAST text detector to improve accuracy and performance. The OCR process comprises the following stages:

1. Preprocessing
   This step reduces noise and enhances the clarity of the image captured by the webcam. Techniques such as smoothing, thresholding, and normalization are applied to ensure characters have uniform size, orientation, and alignment. This step is crucial for improving recognition accuracy.
2. Segmentation
   In this stage, the processed image is broken down into lines, words, and individual characters. Each segmented element is then isolated for independent recognition. EAST (Efficient and Accurate Scene Text Detector) assists in detecting text regions before segmentation.
3. Feature Extraction
   Key features of each character are extracted using pattern recognition methods. These features include structural attributes like lines, curves, and intersections that help differentiate characters.
4. Classification
   The extracted features are compared against a trained dataset using machine learning algorithms embedded in the Tesseract OCR engine. The engine maps the unknown characters to known classes and generates digital text output.
5. Post-Processing
   The final step involves correcting any errors using language models or dictionaries. Grouping of characters into meaningful words or sentences is also carried out here. This ensures coherent and accurate voice output.

This multi-stage methodology ensures that the system achieves high accuracy in detecting and converting printed text into speech, providing real-time auditory feedback to the user.

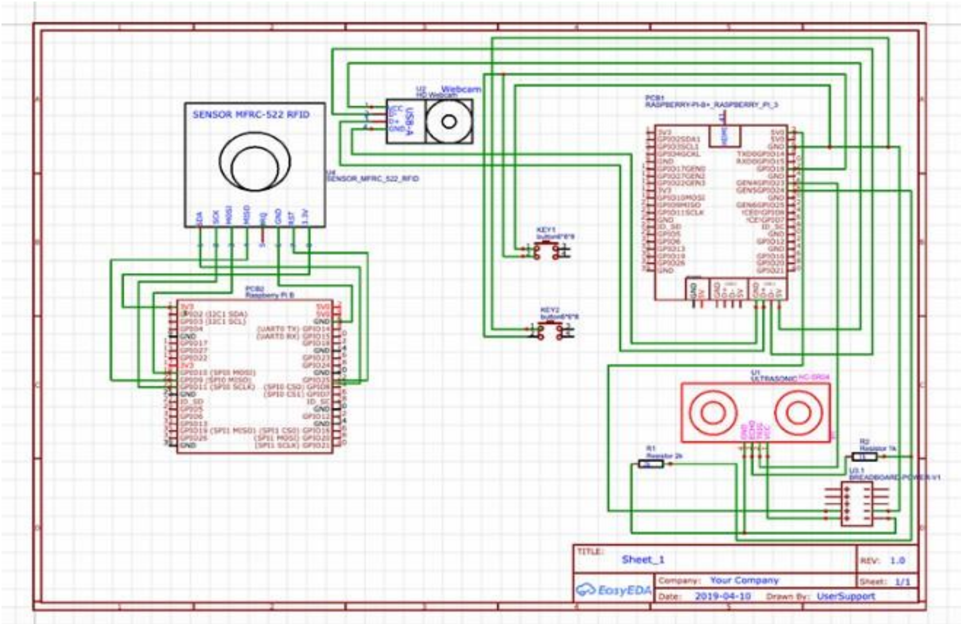


OCR Mechansism

SYSTEM WORKFLOW

The operation of the smart glasses begins when the user presses a designated button to initiate the reading process. An ultrasonic sensor immediately checks the distance between the camera and the target object to ensure it falls within the optimal range of 40 to 150 cm. If the distance is appropriate, the webcam captures an image containing text. This image is then processed using the OCR engine, which detects and extracts the text content. The extracted text is converted into audio using the Google Text-to-Speech (gTTS) engine and

played through headphones, allowing the user to hear the content. If the user presses a secondary button, the system also translates the recognized text into Arabic using the Google Translate API before vocalizing it. Simultaneously, RFID sensors positioned on the glasses can detect nearby RFID tags, such as those placed near classroom doors, and inform the user about their current location through voice feedback. This seamless integration of sensors and software provides a real-time, interactive assistive experience for visually impaired individuals. the gap between mechanical design and intelligent electronics to bring innovative, real-world solutions to life.



Schematic architecture

ADVANTAGES

1. Enhances independence of visually impaired users in academic and daily environments.
2. Offers multilingual translation.
3. Affordable and scalable prototype for widespread use.
4. Real-time voice guidance ensures ease of navigation and reading.

VII. LIMITATIONS

1. Only supports English text recognition.
2. Optimal image capture distance is limited (40-150 cm).
3. Device bulkiness due to Raspberry Pi positioning.
4. RFID range limited to approximately 3 cm.

VIII. CONCLUSION

The smart glasses system effectively addresses several challenges faced by visually impaired individuals, especially in academic settings. It demonstrates how embedded systems and open-source tools can be combined to develop cost-efficient and practical assistive devices. The system promotes user autonomy through real-time voice feedback and enhances learning environments for blind users by converting text into audio and recognizing physical locations using RFID. With its modular structure and affordability, this prototype serves as a foundation for future assistive technologies.

Future work may include optimizing the device's size by replacing the Raspberry Pi with smaller microcontrollers such as the Raspberry Pi Zero or ESP32 for a more ergonomic fit. Expanding the OCR to support multiple languages and handwritten text would significantly broaden the device's applicability. Additional improvements could involve integrating GPS for outdoor navigation, enhancing RFID range, and developing a smartphone-based companion app for cloud storage, software updates, and remote configuration. Advancements in low-power electronics and machine learning could also enable on- device object detection and facial recognition, further enriching the user's interactive experience.

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