VISIONMATE: SMART ASSISTIVE GLASSES FOR THE VISUALLY IMPAIRED

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ABSTRACT:

Visual impairment affects over 2.2 billion people worldwide, limiting their independence and access to information. Traditional assistive devices often lack real-time environmental awareness, text recognition, and navigational support. This project proposes Smart Assistive Glasses for the Visually Impaired using Raspberry Pi Zero 2W equipped with camera and GPS module. The system integrates YOLOv3 Tiny - based object detection, Optical Character Recognition (OCR), and text-to-speech synthesis for real-time assistance. IoT integration through Blynk allows emergency alerts and remote monitoring. The proposed system aims to demonstrate enhanced object recognition, accurate text conversion to speech, and effective location-based alerting, significantly improving mobility and daily life independence for visually impaired users.

Keywords:-Smart Glasses, Visual Impairment, Object Detection, OCR, Text-to-Speech, IoT

1. INTRODUCTION:

Visual impairment is a global challenge affecting approximately 2.2 billion people according to the WHO-2023, many of whom struggle with independent mobility and accessing information. Conventional aids like white canes or audio-based tools provide limited context about the surrounding environment or textual information. Advances in embedded systems, computer vision, and IoT enable innovative solutions that provide real-time environmental awareness and guidance[5][6]. Wearable devices using low-cost hardware like Raspberry Pi offer portable, efficient, and scalable solutions for the visually impaired population. These systems can bridge the gap between traditional assistive devices and modern AI-powered smart aids [8].

Despite the availability of assistive technologies, visually impaired individuals still face challenges in navigation, obstacle detection, and text comprehension. Current solutions often rely on manual intervention, lack accuracy in real-world conditions, and fail to integrate multiple assistance modalities like object detection and OCR in a single device. There is a need for a compact, affordable, and efficient wearable device that can simultaneously detect obstacles, read text from the environment, convert it into speech, and provide location-based assistance through IoT.

The proposed system holds significant potential to improve the quality of life for visually impaired individuals. By integrating object detection, OCR, text-to-speech synthesis, and IoT-enabled emergency alerts, the glasses enhance independence, safety, and access to real-world information. The smart glasses use a camera and object detection to guide safe navigation, while OCR with text-to-speech enables reading printed or digital text aloud. A GPS module linked to IoT (Blynk) shares real-time location and emergency alerts, allowing caretakers to monitor and assist remotely, enhancing independence and safety. This system can serve as a blueprint for low-cost, intelligent wearable solutions, demonstrating how technology can empower millions globally.

The primary objective of this project is to design and implement smart glasses that assist visually impaired individuals in daily activities. The system aims to detect obstacles and objects in real time, read and translate text, convert textual information to speech, and send location-based alerts through IoT. Additionally, the project seeks to utilize a Raspberry Pi Zero 2W with GPS modules to create an affordable, portable, and efficient solution. By combining computer vision, embedded systems, and IoT, this device aims to increase independence, mobility, and safety for visually impaired users.

2. LITERATURE REVIEW:

1. Murali et al., (2025) presents *"Ultrasonic Goggles for Blind Assistance"* wearable smart glasses integrating ultrasonic sensors, a control unit, and a buzzer to detect obstacles within 20 cm to 3 meters. Unlike traditional white canes and guide dogs that face limitations such as high costs, training, or inability to detect overhead barriers, this system provides affordable, lightweight, and portable assistance with real-time auditory feedback[1].

2. The recent work by Ghosh et al. (2024) "*Third Eye for Blind People*" advances this field by introducing smart ultrasonic glasses integrating Arduino Nano, dual ultrasonic sensors, piezo buzzers, and vibration motors to assist visually impaired individuals with obstacle detection. This system provides real-time auditory and haptic feedback through varying beep intervals and vibrations based on proximity to obstacles. Prior works have emphasized ultrasonic or sensor-based navigation aids, but often encountered issues with single-functionality, bulkiness, or environmental sensitivities, whereas this design prioritizes affordability, portability, and resilience to dust, rain, or snow[2].

3. Busaeed et al. (2022) introduces LidSonic, affordable smart glasses for the visually impaired, integrating LiDAR, ultrasonic sensors, Arduino, and a smartphone app. Unlike costly camera-based systems such as eSight or Orcam, LidSonic minimizes computation by processing LiDAR integer data rather than image streams, reducing power and memory needs. Prior research on sensor, vision, and hybrid systems showed trade-offs between cost, precision, and usability, leading to low adoption[3].

4. *"Smart Glasses for Blind People Using Raspberry Pi Zero 2W"* presents an assistive device combining a high-resolution camera, Raspberry Pi Zero 2W, and audio output to aid visually impaired individuals. Unlike traditional aids or costly commercial glasses, this solution leverages computer vision, OCR, and face recognition to provide real-time auditory feedback for navigation, reading, and interaction. Prior works have focused on sensor-based, IoT-enabled, or deep learning glasses but often faced challenges of cost, bulkiness, or high power consumption[4].

5. The paper *"Smart Glasses Using IoT and Cloud for Visually and Physically Impaired People"* (Jain et al., 2023) proposes a multiutility wearable system that integrates IoT, deep learning, and cloud support to assist visually and physically impaired users. Unlike traditional aids, these smart glasses combine ultrasonic sensors for obstacle detection, ESP32-CAM for object recognition, DHT11 for environmental monitoring, and GPS/GSM for location tracking. Prior works, such as Google Glass and sensor-based navigation aids, often faced challenges of cost, limited scope, or poor adaptability [5].

6. Independent navigation remains a major challenge for visually impaired individuals, as traditional aids offer limited information about their surroundings. To address these gaps, Farooq et al. (2022) introduced *"IoT Enabled Intelligent Stick for Visually Impaired People for Obstacle Recognition"* a dual-mode assistive device integrating ultrasonic sensors, water detection, GPS/GSM modules, and Raspberry Pi- based image recognition. Unlike earlier smart sticks that relied mainly on ultrasonic sensing mic adjustments, IoT-based global tracking, and contextual voice alerts. Prior solutions often suffered from limited range, bulky design, or absence of object-specific recognition. By combining sensor fusion, IoT connectivity, and machine learning, this prototype enhances safety, usability, and independence for visually impaired individuals[6].

7. To address *"Camera-Based Navigation System for Blind and Visually Impaired People"* Mohamed et al., 2023 presents a wearable smart glasses prototype integrating a Raspberry Pi, camera, and ultrasonic sensor for multimodal assistance. The system operates in three modes: object detection using deep learning (SSD with COCO and custom datasets), face recognition for identifying familiar people, and text reading via OCR. Unlike smartphone-based apps or costly smart canes, this design emphasizes affordability and offline real-time performance. Prior solutions often required internet connectivity, were expensive, or lacked adaptability. This prototype advances independence by offering object, face, and text recognition through audio feedback[7].

8. Navigating retail spaces independently remains challenging for visually impaired individuals due to limited object recognition and accessibility support. Sweatha & Priya (2024) address this with *"YOLOv5 Driven Smart Glasses for Visually Impaired"* an AI-based interactive shopping assistance system designed to enhance accessibility in retail spaces. The prototype

integrates a Raspberry Pi 4, camera, ultrasonic sensor, and YOLOv5 for real-time object detection, combined with OCR and gTTS for multilingual text-to-speech output. Unlike earlier smart canes or YOLOv3-based glasses, this system emphasizes improved detection accuracy, multilingual support (English and Tamil), and affordability. This work advances inclusivity by offering personalized assistance, real-time environmental awareness, and greater independence [8].

3. METHODOLOGY:

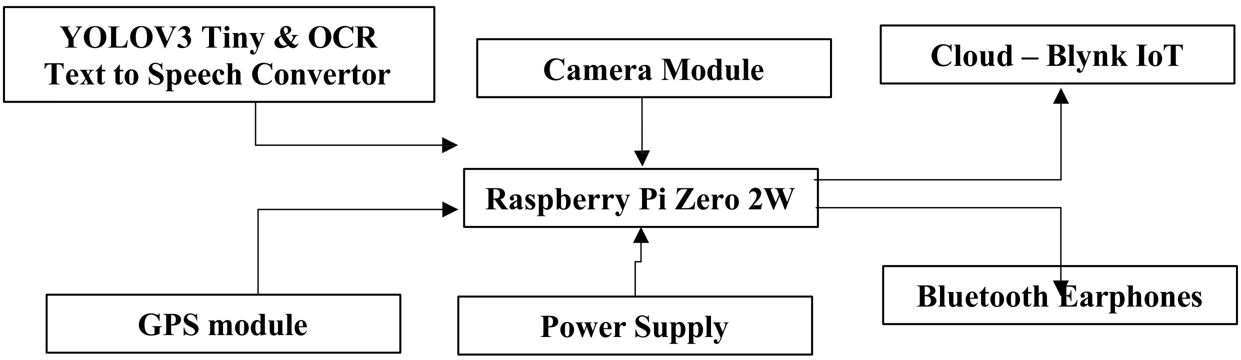

Figure 1. Block Diagram of Methodology:

This Methodology uses a Raspberry Pi Zero 2W as the main processor to create a smart system. Here's a simple breakdown of how it works:

1. Setting Up the Core Components:

- The Raspberry Pi Zero 2W is the central device that runs everything. It's connected to a Camera Module for taking pictures or videos and a GPS module to track the device's location.

2. Adding Smart Features with YOLOv3 Tiny & OCR:

- The system uses YOLOv3 Tiny to identify objects in the camera's images, like people or signs. It also uses OCR (Optical Character Recognition) to read text from those images, such as numbers or labels. A Text to Speech Converter is added to turn the recognized text into spoken words.

3. Connecting to the Cloud with Blynk IoT:

- The Raspberry Pi sends the collected data (like object details or location) to the Blynk IoT cloud, an online platform for storing and accessing information remotely. This lets user's guardian control or check the system from anywhere using an app.

4. Powering the System:

- A Power Supply provides electricity to the Raspberry Pi, camera, and other components, ensuring the system stays operational.

5. Adding Bluetooth Earphones:

- Bluetooth Earphones are linked to the system to deliver audio feedback, such as spoken alerts or instructions based on the camera's findings or location data, making it more interactive.

6. Putting It All Together:

- All parts work in harmony: the camera captures images, YOLOv3 Tiny and OCR analyse them, the Text to Speech Converter speaks the results, the GPS tracks the location, the Blynk cloud stores the data, and the earphones provide audio updates. The power supply keeps it all running. The system would be teste to ensure it works well for tasks like monitoring or navigation.

i. YOLOv3-Tiny

YOLO (*You Only Look Once*) is a popular deep learning algorithm for real-time object detection. YOLOv3-Tiny is a lighter and faster version of YOLOv3, designed for devices with limited processing power like Raspberry Pi. While it sacrifices some accuracy compared to the full YOLOv3 model, it can still detect multiple objects at once with good speed, making it ideal for wearable assistive devices that need quick responses but cannot handle heavy computation.

ii. Optical Character Recognition (OCR)

OCR is a technology that converts printed, handwritten, or digital text from images into machine-readable text. For assistive devices, a camera captures an image of text (for example, from a sign or document), and the OCR software extracts the characters. This allows visually impaired users to access printed information that would otherwise be inaccessible.

iii. Text-to-Speech (TTS) Conversion

TTS is a process that converts digital text into spoken voice output. After OCR extracts text, TTS systems like Google Text-to-Speech (gTTS), pyttsx3, or other speech engines generate audio feedback. This helps users “hear” text in real-time, providing independence in reading tasks.

4. DISCUSSION:

Different research efforts have approached the design of smart assistive glasses in unique ways, but all share the common foundation of computer vision, object detection, and audio feedback. The Arduino IoT and Cloud-based glasses use simple hardware like Arduino Uno, ultrasonic sensors, and ESP32-CAM[5][6]. They are affordable and include extra features such as temperature and humidity sensing, making them useful for basic navigation and hazard alerts. However, because Arduino has limited processing power, the system struggles with advanced tasks like accurate object recognition, text reading, or providing detailed real-time feedback.

On the other hand, the Raspberry Pi Zero 2W, which the proposed system uses- based glasses represent a major step forward. With more computing power, they support YOLOv3 Tiny (Python) -based object detection, OCR, and text-to-speech, giving users richer and more reliable information. Their IoT integration through Blynk allows real-time emergency alerts and caregiver monitoring by sending alerts when in danger, while GPS adds outdoor tracking. This design is not only more compact and energy-efficient but also far more practical for wearable use.

When compared with the YOLOv5-driven Raspberry Pi 4 glasses[8], which focus mainly on high-accuracy object detection and multilingual OCR for retail environments, the Raspberry Pi Zero 2W version demonstrates greater adaptability and safety. While it may use YOLOv3 Tiny instead of YOLOv5, it balances performance with portability, energy efficiency, and IoT-enabled caregiver support—features absent in the Raspberry Pi 4 model.

Overall, while Arduino-based designs highlight affordability and simplicity, and Raspberry Pi 4 models emphasize detection accuracy, the Raspberry Pi Zero 2W system stands out by combining advanced recognition, text reading, IoT connectivity, and GPS tracking in a compact wearable form. This balance of functionality, mobility, and safety makes it a superior methodological approach for real-world use by visually impaired individuals.

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5. CONCLUSIONS:

The review shows how assistive devices for visually impaired people have improved from simple ultrasonic sticks to smart glasses and IoT-enabled systems. Earlier tools mainly detected obstacles but could not recognize objects or provide much feedback. With the use of deep learning models like YOLOv3 Tiny, OCR for text reading, and text-to-speech, modern devices now give real-time information about objects, people, and text around the user. Adding GPS and IoT features has also improved safety by allowing emergency alerts and location tracking. Newer systems using compact hardware, such as Raspberry Pi Zero 2W, make the devices lighter, more affordable, and practical for daily use.

These developments show a clear move from basic navigation aids to complete support systems that improve independence, safety, and confidence for visually impaired individuals. Future work should focus on reducing power use, improving real-time accuracy, integrating AR or edge AI and making these devices widely available at a low cost.

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