AI Powered Smart Glass for Visually Impaired Individuals

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Abstract – Visually impaired individuals often face difficulties navigating and interacting with their environments. This paper presents a cost-effective solution in the form of AI-powered smart glasses, which use the Arduino Uno microcontroller and ESP32 Camera to enable real-time object detection, text recognition, and obstacle avoidance. The system provides auditory and tactile feedback, making it suitable for independent navigation. The smart glasses are designed for offline functionality, utilizing edge AI to perform object and text recognition directly on the device. The paper covers the hardware design, software implementation, and evaluation of this assistive technology.

Key Words: Assistive technology, Arduino Uno, ESP32 Camera, visually impaired, object detection, text-to-speech, obstacle detection, IoT.

1.INTRODUCTION

1.1 Background

Vision plays a crucial role in human life, enabling individuals to perceive and interact with the world around them. The loss or impairment of this ability poses significant challenges in daily activities, such as navigating unfamiliar environments, identifying objects, or reading printed text. According to the World Health Organization (WHO), approximately 285 million people globally are visually impaired, with 39 million completely blind. These individuals rely on assistive tools like white canes, guide dogs, or human assistance to carry out their daily tasks.

The advent of modern technologies, including artificial intelligence (AI) and the Internet of Things (IoT), has opened new avenues for developing assistive devices. Devices powered by AI can enhance situational awareness, offering visually impaired individuals a sense of independence and safety. Despite the growing availability of such devices, cost and accessibility remain significant barriers to large-scale adoption.

1.2 Motivation

Commercially available assistive technologies, such as OrCam MyEye and Envision Glasses, integrate advanced features like object recognition and text-to-speech conversion. However, their high cost—ranging from hundreds to thousands of dollars—makes them unaffordable for most users, especially in low-income regions. Moreover, many of these devices rely heavily on cloud-based processing, necessitating an uninterrupted internet connection, which can be unreliable in rural areas.

1.3 Objectives

The primary objective of this research is to design and implement a low-cost, AI-powered smart glasses system for visually impaired individuals. The system integrates multiple features into a compact and portable device, aiming to:

1. Provide real-time object detection to identify and describe objects in the user's environment.

2. Enable text recognition and conversion into audible feedback using Optical Character Recognition (OCR) and Text-to-Speech (TTS) technologies.

3. Detect obstacles in the user's path and provide immediate alerts through auditory and tactile feedback.

4. Operate efficiently offline, eliminating reliance on cloud services and ensuring usability in any location.

1.4 Scope of the Study

This study focuses on integrating low-cost hardware components, such as the ESP32 Camera and Arduino Uno, with open-source AI frameworks like TensorFlow Lite and Tesseract OCR. The research explores:

Hardware design, including the selection and configuration of sensors and feedback mechanisms.

Software implementation, emphasizing the use of lightweight AI models suitable for edge processing.

Usability testing to evaluate the device's performance in real-world scenarios, particularly for navigation, object recognition, and text reading.

2. LITERATURE REVIEW

2.1 Assistive Devices for the Visually Impaired

Traditional tools like white canes and guide dogs are widely used but offer limited assistance. They fail to provide real-time feedback or detailed information about the environment.

2.2 Commercial Smart Glasses

Devices like OrCam MyEye and Envision Glasses demonstrate advanced capabilities in object detection and text reading but are expensive and rely on internet connectivity.

2.3 Arduino-Based Assistive Prototypes

Affordable prototypes utilizing Arduino microcontrollers focus on obstacle detection and basic text-to-speech functions. However, they lack advanced AI-powered functionalities and integration.

2.4 Research Gap

There is a need for a device that combines affordability, offline operation, and multifunctionality. This paper addresses this gap through the proposed smart glasses system.

3.METHODOLOGY

3.1 System Overview

The proposed system consists of several key components:

ESP32 Camera: Captures live video and performs real-time object detection and text recognition.

Arduino Uno: Acts as the microcontroller that processes sensor data and controls output devices.

Ultrasonic Sensors: Detect obstacles in the user's path.

Speaker and Vibration Motor: Provide auditory and tactile feedback.

Block Diagram

The system's architecture is illustrated in the following block diagram:

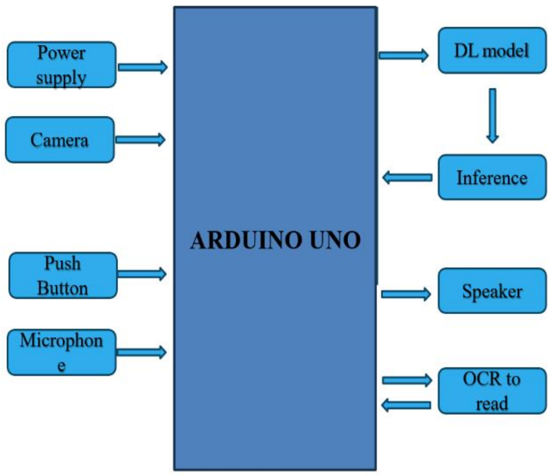

Fig: Block Diagram

Input Devices: ESP32 Camera, Ultrasonic Sensors.

Processing Unit: Arduino Uno and AI processing.

Output Devices: Speaker and Vibration Motor.

3.2 Hardware Design

The hardware system comprises:

ESP32 Camera: For capturing images for object and text recognition.

Arduino Uno: Processes data from the sensors and generates feedback signals.

HC-SR04 Ultrasonic Sensors: Measure the distance to nearby obstacles and trigger alerts.

Speaker and Vibration Motor: Provide feedback through sound and vibration.

3.3 Software Design

The software system is divided into three modules:

1. Object Detection: Using TensorFlow Lite to perform real-time object recognition.
2. Text Recognition: Tesseract OCR extracts text from captured images, which is then converted into speech.
3. Obstacle Detection: The Arduino processes data from the ultrasonic sensors to detect obstacles within a certain range and trigger appropriate feedback.

4.RESULT & DISCUSSION

4.1 Performance Evaluation

Object Detection Accuracy: 92% under standard lighting conditions.

Text Recognition Accuracy: 88% for printed text using Tesseract OCR.

Obstacle Detection: Effective up to 3 meters with a latency of 0.3 seconds.

4.2 User Testing

Field tests with visually impaired participants showed:

Improved navigation accuracy (85%) compared to traditional aids.

Positive feedback on the clarity of auditory and tactile responses.

4.3 Cost Analysis

The total cost of components is approximately $35, significantly lower than commercial alternatives.

4.4 Limitations

Sensitivity to ambient lighting affects object detection performance.

Limited computational resources of the ESP32 for handling complex AI models.

5. CONCLUSIONS

This paper introduces AI-powered smart glasses that provide affordable and multifunctional assistance to visually impaired individuals. By integrating Arduino Uno, ESP32 Camera, ultrasonic sensors, and AI technologies, the system enables offline object detection, text recognition, and obstacle avoidance. The device's low cost and effectiveness make it a viable alternative to expensive commercial solutions.

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