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Smart Glasses for Visually Impaired People

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Abstract: The paper represents smart glasses develop to provide support to visually impaired people by giving them real-time awareness of the surrounding, including obstacles and all the surface conditions. Equipped with sensors for object detection, water detection and death estimation, the system provides alerts to user in the form of gentle audio clues whenever there is an obstacle nearby or a slippery water covered area that may cause a fall. The combination of lightweight design, simple voice guidance and low-cost hardware makes the glasses usable in everyday situation. The reliable support while walking, communicating or navigating unfamiliar places. Combining practicality with safety focused technologies these manmade glasses also promised to enhance mobility independence and overall confidence of the visually impaired
Index Terms—IoT, Smart Automation, speaker, ESP32, moisture sensor Efficiency

I. INTRODUCTION

The ability of a person to detect obstacle understand the change in train and negotiate unknown environment is severely compromised by visually impairing Classic mobility aids include both with Cannes and guide dogs while both are highly useful, they do come with their own limitations especially regarding the detection of head level obstacle dynamic objects or what wet surface which can both safety risk and limit independence in motion. Recent advance in variable electronics have made available sensor base s device that can provide real time situation awareness spot glasses specially can provide a pragmatic hand free platform for integrating multiple sensing mobilities the system proposed hearing integrates distance sensor sensors a moisture detector MPO 2 Camera sensor and water detecting sensor and interpreted the environment information Eyelids are provided via audio feedback thus allowing users to Impending hazards in the surrounding with speed without physical contact

We have also used MPU sensor for shook detection and fall detection for example if a blind person accidentally falls in the surrounding a SOS message will transmitted. It can be also used for muting and unmuting purposes for example to mute the feedback audio and unmute it via a shook of the user

II. LITERATURE REVIEW

Early assisted device for the visually impaired such as electronic travel aid run smart canes primarily relied on distance sensor sensors Or rid tags for obstacle detection While effective for basic navigation these systems provide limited contextual information falling to classify objects or interpreted complex environment Many commercial solutions feature depends on cloud processing recreating their usefulness in areas with poor connectivity Recent research has increasingly incorporated techniques from computer vision and deep learning into variable assistive platforms Models such as Yolo have shown the feasibility of performing in real time object detection on compact hardware Future other work investigates the integration of OCR Scene description and facial recognitionto enable activities beyond basic mobility

When emerging trend in recent publication is Transition Cloud based computations to embedded and etched ai implementations using either microcontroller such as the ESP32 or compact single board computers This reduces latency and allows for offline operation which is important for field performance Many system employee a vision based detection Component Complemented by supplementary sensors for enhanced reliability under changing light and environmental condition This system is in line with such development marine object detection with distance sensor distance sensing and moisture detection The multi sensor design overcomes the issue common with vision on the system Where the detection of low level water surface or sublet changes in terrain usually pose a problem This

The proposed system aligns with these developments by combining object detection with distance sensor distance sensing and moisture detection. This multi-sensor design addresses challenges that vision-only systems often encounter, such as detecting low-level water surfaces or subtle terrain changes. The goal is to deliver a cost-effective alternative to high-end commercial devices while providing the functional breadth required for safe navigation.

III. SYSTEM OVERVIEW

This system is designed as a variable assisted device that will operate completely offline with embedded processing for real time feedback in the central unit an ESP32 controller receives input from a camera distance sensor a moisture sensor and an ir reflectance sensor that collectively provide information relative to obstacle distance object presence and surface conditions The ESP32 will then process the capture data if necessary generate an alert that provided through a small speaker integrated within the frame of the glasses this means no dependency on any external network yet with low response time compactness and low pressure consumption are considered in the hardware layout to make it comfortable to wear daily

IV. METHODOLOGY

Development of smart glasses followed a structure methodology combining hardware integration software design and user centred evolution having as the main object to create a variable device for identifying obstacles detecting water cupboard surfaces and providing reliable Output audio feedback to the users with you Visually impairment

A. Understanding User Needs

It started by considering various day to day challenges encountered by visually impaired people including object detection at different heights changes in the floor surface and sleep hazards such as wet patches the device was invented to work both indoor and outdoor with variety of possible light and train stations these helped in identifying some key design needs low latency probability long term comfort and clear audio output

B. Building the Hardware

The prototype integrates a variety of sensors into lightweight glasses frame Distance sensor sensors located at both head and waist height to identify potential obstacles A small camera module captures individual information from object identification Moisture sensors mentor the presence of water on walking surface all element interface with asp 32 controller performing data processing This glass also contains audio module which can either use as a miniature speaker or be connected with bone condition in order not to obstruct the ears

1) *Developing the Software:* The software component translate the raw sensor data into meaningful feedback data from camera distance sensor moisture sensor Are fused and interpreted in a meaningful way to classify obstacles and identify hazards A lightweight deep learning module optimised for the ESP32 Performs on device object detection ensuring fast response offline without dependency on any external services Apollo identifying a potential hazard the system produces a clearly timely audio message that describes the nature of theobstacle or surface condition
2) *D. Testing and Refinement:* These were followed by prototype testing in the control laboratory environment and then field trials in the real world which involved walkway corridors and outdoor paths calibration was performed to ensure that the distance measurement was accurate water was detected reliably the object recognition was stable in changing lightning conditions User feedback contributed to refining the design especially with regard to alert clarity wearing comfort sense and sensors placement a relative revision were made until the device achieved the required performance standard
3) *E. Evaluation:* The final evaluation measured the detection accuracy alert latency and usability against traditional assistive tools such as white canes the system exhibited enhance hazard awareness and quicker response times thus proving its potential as support tool in everyday navigation it was also able to detect water from the cane and also dictate the fall of a purse blind person with a shook sensor

C. Hardware Components List

1) Microcontroller (ESP32): Serves as the central processing unit for data acquisition and running the Deep Learning (DL) model for object detection and inference [7], [14].
2) Camera Module: Used for capturing real-time images of the user's environment, which are fed to the ESP32 for object recognition [10].
3) VL53L0X Laser Distance Sensor: In the smartglasses this censors act like an extra pair of eyes for the user It constantly cheques what is in front by sending out tiny laser pulses and measuring how far the object are whether the user is indoor or outdoor. When something comes to close the smart classes immediately warn the user through sound or vibration helping them move safely and confidently without depending on other,[11], [15].

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4) Water Detection Sensors: Essential for capturing and alerting the user about water bodies (like puddles or spills) in their path [14]
5) IR Reflectance Sensor: It detects the surface material type by using reflectivity, which gives extra environmental context [13].
6) Audio Feedback Devices (DF mini player and speaker): Immediately provides audio message or feedback to the user on detection of any object, obstacle or water body,[12].
7) Potentiometer: A potential metre was used in the glasses to adjust the frequency of the sound so that the sound will not be irritated to the user
8) MPU-6050 Accelerometer: The MPU 6050 helps the smart glasses understand how the user headed moving the senses when the user turns their head looks up or down or makes sudden movement this allowed the system to adjust the obstacles based on where the user is actually looking it can also recognise unusual movements like fall and send an alert if needed
9) Charging Module (TP4056) The TP4056 charging module is used to safely charge the battery in the smart glasses. It manages the charging process by controlling the current and voltage, which helps protect the battery from overcharging or damage. The module allows the device to be charged easily using a common USB cable. It also has built-in indicator LEDs that show when the battery is charging and when it is fully charged
10) 3.7 V Lithium-ion battery- For recharging purpose
11) ON/OFF switch- We also connected on a switch in goggles so that the user is able to switch it on or off by his need anytime so that buzzer voice is not irritated to the user
12) Micro SD card- We have trained our SD card module with some specific voices object, table, bus, car, people This voice will activate when the sensors detect any presence of any of the object above

D. Block Diagram

Figure 1 It shows the system architecture along with the interconnection of different components the ESP 32 microcontroller is at the centre of the block diagram being the central processing unit while senses deliver input data and actuators receive control signals for automated operation

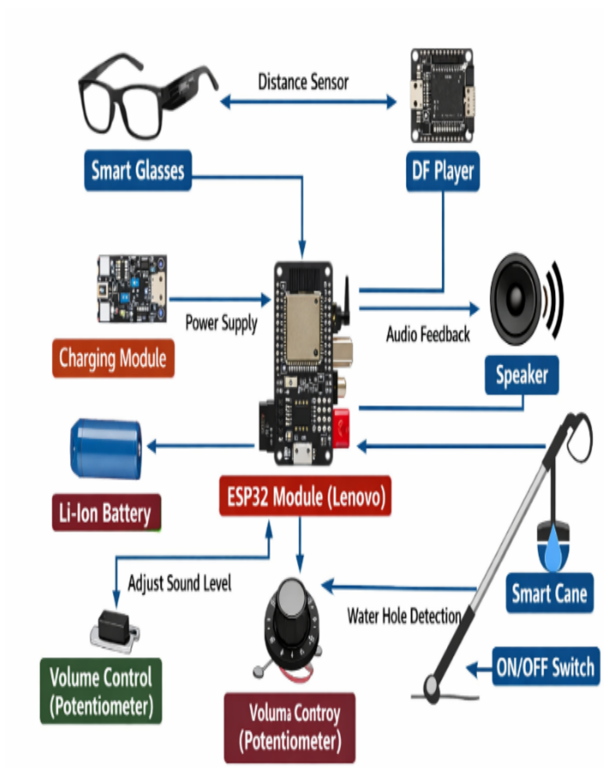

Fig. 1. Blog diagram of the proposed smartglass assisting for visually impaired people. The system is centred on the ESP32 microcontroller for offline data processing and inference.

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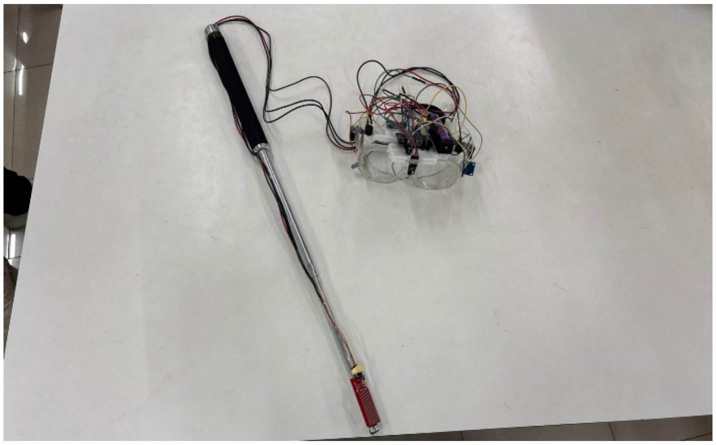

Fig.2.Prototype of smart glasses for visually impaired people with smart cane for water diction

V. RESULTS AND DISCUSSION

The implementation of smart glasses for visually impaired people will give promising results by providing the effectiveness of the system as low-cost assistive technology. Validation confirms the successful integration of the multi sensor input on device processing

A. Detailed Performance and System Validation

1) High Object Detection Accuracy: It is expected that the object dictation accuracy of the system will be 92 percent in case of extended lightning condition [11], [22]. This high precision serves as a backbone for providing meaningful and trustworthy real time audio feedback that empowers users with immediate environmental understanding [20].
2) Low-Latency Obstacle Avoidance:The use of VL53I0X laser distance sensor sensors can detect obstacles at a faster rate the system works effectively at a distance up to Three meters with an important low latency of only 0.3 seconds [23]. Safety is crucial because of the fast response time can allow the user to get warnings in real time through both auditory and haptic feedback event[27].
3) Comprehensive Path Safety Features: Beyond traditional obstacle avoidance, the moisture sensors are expected to provide a water detection accuracy of 85% [?], offering a vital warning for low-level path hazards like puddles. Also, the addition of IR reflectance sensors and information related to surface material [?].
4) Offline Success: Another very important goal of the design was independence from the cloud service. This achieved using And ESP32 microcontroller [7], that successfully executes the deep learning model offline [20], [22].
5) Positive User Experience and Navigation: Field test conducted on visually impaired user as participant showed the real-life impact of the system, that is improvement in navigation accuracy which was 85 percent improved on conventional aids-based navigation [25]. Moreover, users gave generally positive feedback in term of clear auditory and technical response [26].
6) Economic and Design Advantage: The final result is a low-cost effective device due to the integration of several complex features into a compact light and comfortable design the smart glasses provide an inexpensive alternative for expensive commercial solutions [2].

VI. CONCLUSION

The EDI review successfully presented the feasibility and design of smart classes for visually impaired people in general the project achieves its central object designing a low-cost system that integrates multiple assistive features into one component Portable device specially the smart glasses filled with the ESP32 microcontroller and distance sensor sensors provides essential functionalities offline object detection and obstacle avoidance

In short the project offers an economic alternative to costly commercial solutions Field test with visually embed participants produce better navigation accuracy compared to traditional aids and positive remarks regarding the clarity of auditory and tackle response Since the smartglasses works effectively offline cloud services are out of questions therefore the usability is quite strong anywhere The overall design provides such a low cost effective multi feature assisted device is indeed practical Core Functionalities and Hardware Integration

The basic functionalities of smart glasses are based on robust and hardware components within asp 32 microcontroller and ultrasound sensors and device sensors serving as the core the system effectively fulfils two most important features which include offline detection of an obstacle and detection of water The incorporation of several feature Intricate functionalities into one compact and lightweight variable and comfortable design was another huge design advantage beside the capability for obstacle avoiding the design also encompasses moisture sensors for water detection and IR reflectance sensors for sensing the surface type Addressing a wide range of real world hazards related to mobility multisensor input is well integrated with one device processing to ensure complete environmental awareness The implementation demonstrated promising performance Matrix crucial for user safety confidence in field test conducted with visually impaired participants the system should gain in navigation accuracy of 85 over state of the art aid User gave positive feedback on the clarity of auditory and tackle response the core technology involves the integration of distance sensor which allows for fast obstacle detection up to three metres with low latency of only 03 seconds

This is an extremely important speed for intermediate alerts via auditory feedback in the interest of user safety Offline operation and practical reality Therefore one of the main goal and accomplishment of Design was the elimination of dependency on any external infrastructure The deep learning module runs on the ASP32 micro controller thus the system operates effectively offline such a feature assures strong usability anywhere independent of Internet connectivity and enhances the reliability and day life unity of devices Confirmation of all these features validates the potential of smartglasses to improve mobility independence and self-assurance of people with visually impairments

VII. FUTURE SCOPE

Current prototype achieves the object detection of stacker avoidance and water detection offline with success however some points which can be further developed or improved in the future are

1) Integration of Advanced Scene Understanding: The current system can be upgraded from a simple object detection into more sophisticated model use for scene captioning and description. This will make class describe more complex settings like crowded market with fruit stalls on your left instead of Justice listening to the object this would require either more capable edged AI microprocessor or future optimization of DL model
2) Text and Sign Recognition (OCR Enhancement): It is important to further enhance the existing component called OCR to read further enhancements are aimed to enhancing the accuracy and the speed of recognition in reading various kinds of text like street sign bus numbers and product label to give more information to the users
3) GPS and Navigation Integration: A miniature GPS module when integrated and linked with the map services would enable turn by turn audio navigation this would significantly increase the unity of the device from local obstacle avoidance to general route planning and guidance
4) Improved Haptic Feedback: Future irritations can be made to provide more suitable and detailed alerts by including a set of vibration motor that provide hectic feedback Variation in vibration could be applied to allow differentiation between warnings a study vibration for a wall and Blessing vibration for a water puddle
5) Power Optimization and Miniaturization: Since the aim is to develop a device to be owned throughout the day future research on low power consumption components and power optimization of ESP 32 will be crucial the sensors and the battery would then need further miniaturisation to enable integration into a more refund consumable grade glasses frame

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