IoT Based Aid Device for Visually Impaired People

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Abstract. Approximately about 37 million people across the globe suffer from visual impairment and that more than 15 million of these are in India. The visually impaired person uses braille for the activities of reading, writing and communicating, and usually needs someone for guidance. But in this particular subject, the greatest obstacle encountered by the visually challenged people is moving from one place to another without any form of support. Recent advances in technology including IoT (Internet of Things) have brought forth modern ways of improving the lives of disabled persons. In this paper, a description of the process of designing and systematically developing the smart wearable device, an aid for people with visual impairments, is presented. The system uses ultrasonic sensors, GPS (Global Positioning System), GSM (Global System for Mobile Communication) and feedback components like buzzer and vibrator to provide information on the surroundings in real time. This wearable device assists the user in orienting and mobility by warning them through vibrations and sounds when using the device and another internal unit where the United States military coordinates cross referencing the perceptions. It is further comprised of a communication interface for a GSM module and a GPS module enabling the gadget to send current location information in times of crisis. The given device is controlled by an Arduino Uno microcontroller. It is oriented towards economy and the possibility of further development. People who are undergoing clinical trials confirm that the provided device has optimized the mobility and autonomy of visually impaired people in terms of urban planning.

Keywords: IoT, visually impaired, wearable device, ultrasonic sensor, GPS, GSM, obstacle detection, Arduino.

1 Introduction

The Internet of Things (IoT) has transformed those technologies and is becoming integrated within a wide range of industries such as medical care, smart houses, and smart devices. Among this population, it is particularly difficult to move around independently in urban areas where there might be dynamic and risky structures [1]. On the other hand, walking canes and guide dogs are useful but there is no cure for their range and value, respectively. Hence, there is a growing

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popularity for smart devices with IoT technology, which help with walks by providing feedback in the process of walking.

In this project we propose and implement a wearable IoT based aid device. This aid has been developed primarily for the visually challenged community. In the developed system an ultrasonic sensor (HC-SR04) is included for the detection of barriers, GPS Neo-6M module serves the purpose of position tracking and GSM SIM800 module helps in sending emergency messages. The user is aided with feedback through a buzzer and a vibrator when the associated obstacles are within a certain distance. The combinational aspect of the system is powered by the Arduino Uno which also makes use of low power, low cost, and easy fabrication. The primary intention of this project is to improve the movement and security of visually challenged people making it cheaper than other existing aids.

The examination of the outcomes of this work shows that the device was able to indicate the presence of an obstacle that was at different distances and offer feedback at appropriate times which is necessary in navigating the users in real-life situations [2]. Further working on this system could include integration to smartphone apps, voice-based feedback systems and use of AI in classifying objects that serve as barriers bettering the functionality and overall experience of the device [3]

2 Literature Review

The assistive technologies, especially used by visually impaired people, are more promising area of research which has been aided by the developments in IoT, wearable and sensor technologies [4]. Many other systems have also been proposed which help in increasing mobility as they replace or supplement the traditional aids like canes and guide dogs [5]. Recently, the function of ultrasonic sensors has been central in the technology related to assistive devices. Ultrasonic sensor systems can also be utilized for obstacle detection due to their distance measuring accuracy and functionality under a range of environmental conditions [6]. Such sensors work by transmitting ultrasonic waves which are reflected back upon meeting an object; this allows the system to compute distance and alert the user accordingly. In 2020, a device that incorporates ultrasonic sensors is worn on the body and detects objects present within the range of the sensors and provides feedback in the form of vibrations was developed by Sharma et al. [7]. This made it easier for the user to avoid obstructions in real time. The drawback of this Sukkar et al. system is that it could only detect near and long-range obstacles, tantamount to the design imperfections [8]. Additional researchers have come up with systems that combine GPS technology with obstacle detection for enhanced navigation purposes. For instance, Bhatia et al. developed a device that integrates GPS and GSM modules to create an innovative panic button device that is used to send SMS alerts to pre-programmed numbers in dangerous situations [9]. Their research revealed that the blend of GSM with GPS in mobility assistance devices is useful, as one can locate the user's position through the help of the family members or caregivers. To begin with, many such devices suffer from delays that are due to the need for all the components to be coordinated and communicate in real time. In 2021, Patel and Gupta introduced an efficient IoT device for the visually challenged people which incorporated Bluetooth technology to connect the sensors to a smartphone where they could receive navigational and feedback [10]. This arrangement confined the power of the device to the extent of how high the power reserve needed to be recharged hence optimizing use of power, which is mostly an issue in clothing or wearable systems. Yet, the present system had challenges related to movement in constrained places with many present obstructions where the device internal processing limits could be exceeded [11]. Overall, existing literature suggests that the use of ultrasonic sensors, GPS, GSM and other IoT components can be successfully employed to develop assistive devices for the visually challenged people. However, more work needs to be done in terms of the accuracy of obstacle detection and energy consumption criteria, as well as the user interface design. This Project seeks to escalate these technologies by developing a device that integrates the western cloudy technologies of the ultrasonic sensor, GPS and GSM in one low-cost and user-friendly device worn by individuals [12]. The system aims at real time classification and detection of obstacles, location tracking and communication during emergencies, thus providing a holistic approach towards enhancing the mobility and safety of visually impaired users. 3 Methodology We present an IoT-based wearable aid device aimed at helping visually impaired individuals navigate their surroundings. The system's main components include an Arduino Uno microcontroller, an ultrasonic sensor (HC-SR04) for detecting obstacles, a GPS module (Neo-6M) for real-time location tracking, a GSM module (SIM800) for emergency communication, and feedback devices like a buzzer and vibrator to alert the user about obstacles. All these components are given as a block diagram and the connections are established in the below figures for better understanding (See Fig. 1 and Fig. 2) [13]. The device is designed to be lightweight and portable, making it easy to wear. Users receive haptic and auditory feedback depending on how close obstacles are, which improves their awareness of the environment [14].

3 Project Subsystem

The proposed model is structured around the following subsystems

3.1 Obstacle Detection Subsystem

The obstacle detection unit uses the HC-SR04 ultrasonic sensor, which works by sending out ultrasonic waves and measuring the time it takes for the echo to re-turn in order to calculate the distance to an obstacle. This sensor is set up to detect objects within a range of 2 cm to 400 cm, making it suitable for real-time navigation in different environments. The distance values detected are processed by the Arduino Uno, which then activates feedback responses based

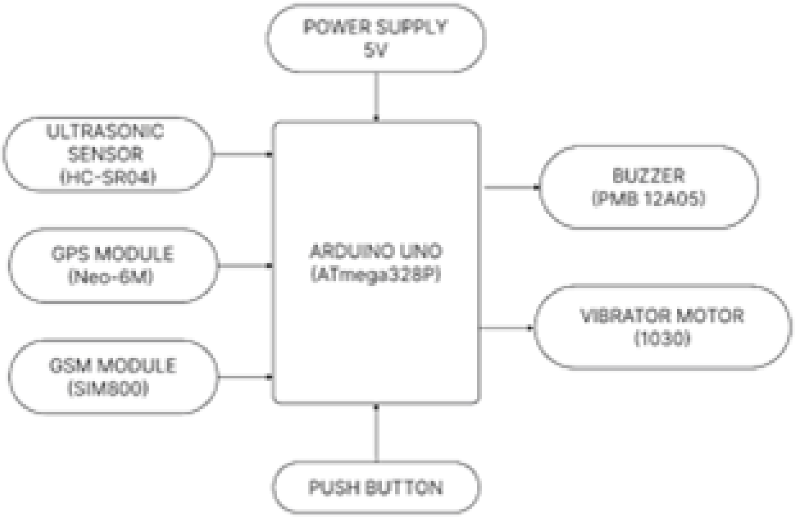

Fig. 1. Block Diagram for IoT based aid device for visually challenged people

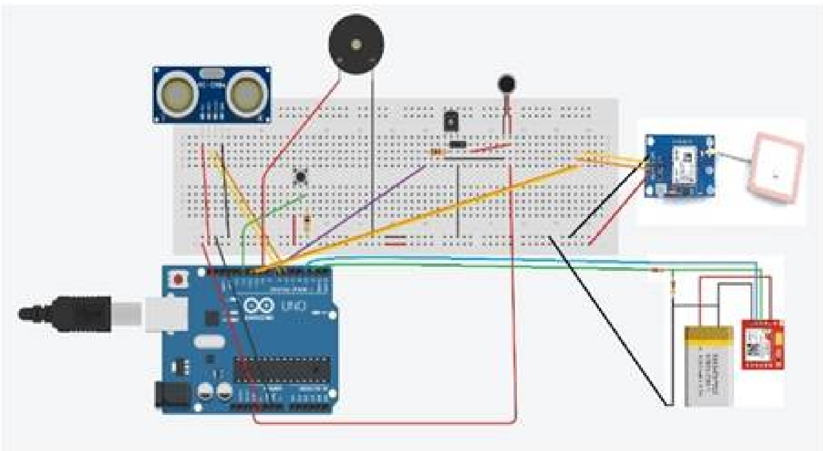

Fig. 2. Circuit diagram for the proposed model

on how close the obstacle is. There are three levels of feedback: 1.For distances greater than 60 cm, a gentle vibration is triggered.
2. For distances between 20 cm and 60 cm, the buzzer produces an audible tone at a medium frequency.
3. For distances less than 20 cm, both the buzzer and the vibrator are activated at a higher intensity, warning the user of a nearby obstacle.

3.2 Location Tracking Subsystem

The GPS module (Neo-6M) keeps a constant watch on the user's geographic location. This feature is especially beneficial for caregivers, allowing them to monitor the user's movements in real-time. If an emergency arises or if the user gets disoriented, their location can be sent to preset emergency contacts via the SIM800 GSM module. This GSM module transmits a text message with the user's GPS coordinates to a list of designated phone numbers, ensuring prompt assistance.

3.3 User Feedback Subsystem

The feedback system includes a buzzer and a vibrator, both managed by the Arduino. The feedback intensity changes based on the distance detected by the ultrasonic sensor. As the user gets closer to an obstacle, the buzzer produces sounds at different frequencies (1 kHz, 2 kHz, and 3 kHz), while the vibrator pulses at various intervals. This multimodal feedback approach guarantees that users receive notifications in a way that is easy for them to understand, no matter the noise level around them.

3.4 Emergency Alert Subsystem

In critical situations, like when the user is lost or faces an obstacle that cannot be navigated, the system enables the user to press a button to send an emergency alert. Once activated, the device transmits a text message with the user's GPS location to caregivers or emergency responders through the GSM module. This feature significantly enhances user safety by providing a dependable communication method during emergencies.

3.5 Power Management

The system is designed for efficient operation with minimal power consumption. The Arduino Uno is powered by a 9V battery, and power management algorithms ensure that the GPS and GSM modules are activated only when needed to save battery life. This approach extends the overall operational time of the device, making it ideal for use throughout the day.

4 Flow Chart

For better understanding of the proposed hardware model, a flow chart has been constructed (See Fig. 3) for step-by-step working operation. A flowchart is an illustration of the flow of a process, system, or algorithm. It applies symbols to represent different kinds of steps and arrows pointing to the sequence of such steps. The below flowchart describes a process for the IoT-based system that uses an ultrasonic sensor to sense objects then produce appropriate outputs. It starts with sensing any object by the ultrasonic sensor. If no object is detected, the loop goes back and the system continues sensing. When an object is detected by the ultra-sonic sensor, it calculates the distance. Then, it checks whether the distance falls within 0 cm to 60 cm. If the distance falls within this range, then it activates the output devices such as a buzzer and vibrator. Meanwhile, when the push button is activated, the system will activate GPS and GSM functionalities to make proper communication or location tracking. The process ends after these steps are fulfilled.

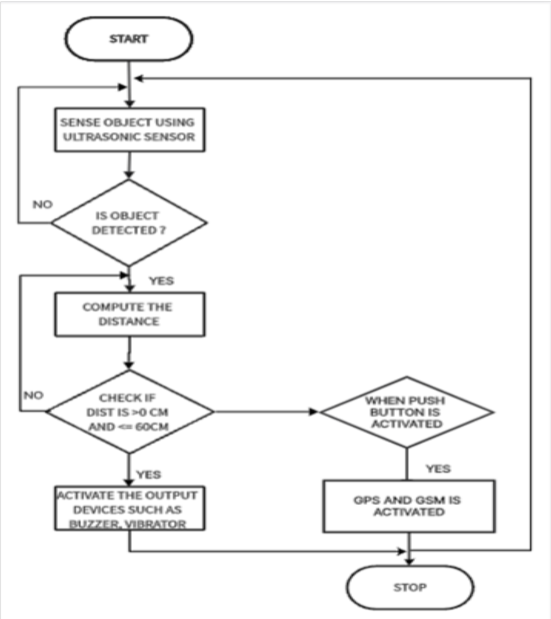

Fig. 3. Flowchart for the working Operation

1. **Start the device** – Power on and initialize components.
2. **Sense the environment** – Ultrasonic sensor scans for obstacles.
3. **Detect obstacles** – Check if an object is within range.
4. **Measure distance** – Calculate distance to the detected object.

5. **Evaluate distance:**
   - If distance < 20 cm, activate intense buzzer and vibrator.
   - If 20 cm $\leq$ distance $\leq$ 60 cm, activate moderate buzzer and vibrator.
   - If distance > 60 cm, no activation.
6. **Provide feedback** – Alert user via buzzer and vibrations.
7. **Repeat process** – Continuously scan and provide feedback.
8. **Stop operation** – Manual halt of the system.

5 Proposed Model

Regarding the block diagram and circuit implementation, a hardware prototype of the smart glove has been developed. The proposed model operates on a 9V power supply, provided by a battery. Programming is executed using Arduino UNO, and the code is uploaded to the circuit.Then the whole model of work was integrated into a glove, which results in the prototype targeted at people with visual impairments as illustrated in Fig 4 and Fig 5.

Fig. 4. Designed Prototype (Bottom of the glove)

6 Results

The IoT-based wearable aid device was demonstrated very effectively showing real-time obstacle detection, GPS tracking, and GSM communication. It employed ultrasonic sensors capable of detecting obstacles in a range of 2 cm to 60 cm. The average response time is below 1 second, which ensures instantaneous feedback in the form of sound and vibration. GPS modules ensure that there is reliable tracking of the location for the user, and coordinates are shared in

Fig. 5. Designed Prototype (Top of the glove)

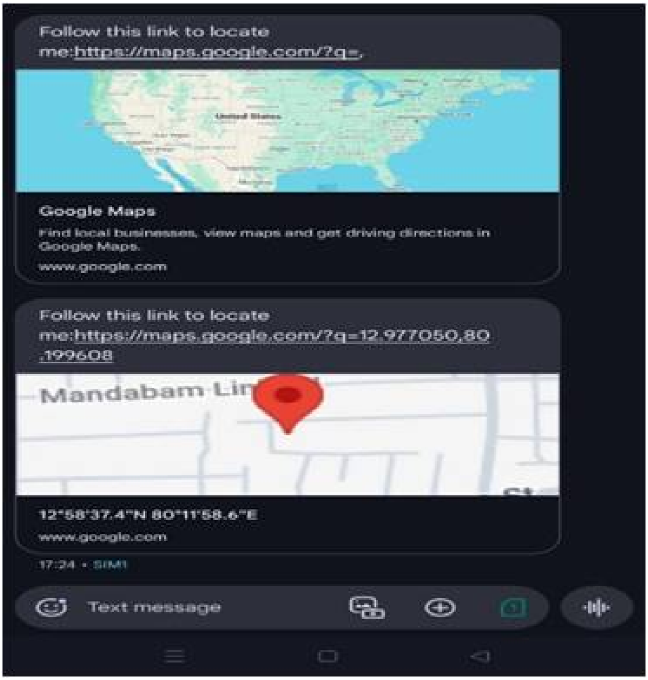

Fig. 6. Emergency message received on the designated contact number

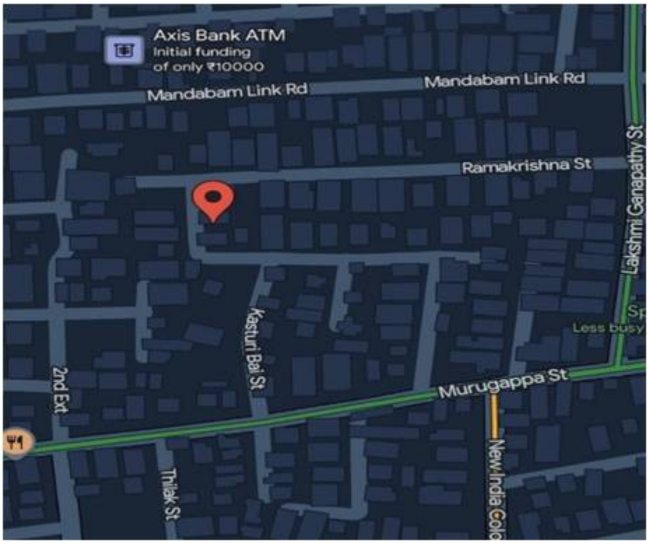

Fig. 7. Shared Location via GSM module

case of an emergency. The SMS was successfully sent by the GSM module at the moment of pressing of the push button with location information. The preliminary testing among blind users also confirmed that the functioning of the device was intuitive and hence the safety increasing with each passing time since it has avoided some potential hazards nearby. (See Fig. 6 and 7).

7 Conclusion

This project successfully created a wearable IoT device designed to assist visually impaired individuals by detecting obstacles in real-time using ultrasonic sensors. The system effectively communicates feedback through sound and vibrations, allowing users to identify obstacles within a range of 60 cm. Early tests indicated that the device is both reliable and easy to use, with quick responses that prioritize safety. This solution aims to improve mobility and offer accessible support for those with visual impairments.

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