Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108

DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

Research Article

Assist Blind People in Road Crossing by Integrating a Smart System into Wearable Devices and Vehicle Applications

Atheer Marouf M. Al-Chalabi
Media Technology and Communications, College of Engineering
University of Information Technology and Communications
Baghdad, Iraq
atheeralchalabi@uoitc.edu.iq

ARTICLEINFO
Article History
Received: 25/06/2025
Accepted: 28/07/2025
Published: 13/09/2025

ABSTRACT
The ability to navigate safely is a critical issue for people with visual impairments, especially in urban cities where traffic flow is a constant danger. While traditional tools such as white canes and guide dogs provide some assistance, they are often limited in detecting fast-moving hazards (such as a vehicle) and lack integration with modern technologies. The goal of this research paper is to create and test a prototype of a smart system based on the Internet of Things (IoT) that will help blind individuals become more aware of their surroundings and be able to get around on their own. There are two primary pieces to the system: a smartwatch that one can wear and a mobile web-based application. The smartwatch is built on the NodeMCU ESP8266 module and has a GPS module, a buzzer, and an LED indication. All of them are built into a comfortable design that can be worn on the wrist. The system keeps an eye on where the blind person is and gets alerts through a real-time Firebase database. The web program runs on the driver's phone, tracks the car's location, figures out how close it is to the blind user, and sends warnings when the predicted arrival time drops below two minutes. We did field experiments at different speeds (10 km/h, 20 km/h, and 50 km/h) across a distance of 2 kilometers. The results demonstrated a high response accuracy exceeding 99.6%, stable GPS accuracy ranging between 96% and 98%, and an average alert response time of less than 1.5 seconds. These results confirm the system's ability to provide immediate alerts and improve the safety of the blind. By combining real-time cloud services, geolocation, and alerts, this prototype provides an effective system that enhances the safety and mobility of blind people in urban environments. The system's performance indicators support its effectiveness in providing two-way interactive alerts and proactive responses to protect the user.

Keywords: *Assist Blind People; Firebase; GPS module; IOT; Smart Devices.*

1. INTRODUCTION

The eye is one of the most important human senses. Through it, they can see and interact with the world. People with vision problems face real daily challenges, especially for their navigation and obstacle detection. These challenges are not just physical, but also affect their ability to work, study, and perform simple daily tasks such as finding their way and moving inside or outside the home. People who are blind or visually impaired often find themselves constantly needing help from others to complete their tasks, which increases the sense of dependency [1], [2], [3].

Statistics indicate that about a quarter of the world's population suffers from visual impairment (visual impairment or blindness). Among them are a billion people who didn't receive the necessary care, who could have been prevented from losing their vision. As a result of that, many people are suffering from moderate to severe visual impairment or even blindness. These numbers call for deep reflection and serious action to change this reality [4].

Today's rapid technological developments, and these technologies have become an integral part of people's daily lives [5], [6], especially the use of smartphones as multifunctional tools to support the visually impaired [7]. However, people with visual impairments and blindness still face significant daily challenges. Although many modern cities rely on intelligent public transportation management systems to improve traffic flow and reduce congestion, these systems are often insufficient to ensure the safety of the visually impaired while crossing the roads

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

[8]. This highlights the need for innovative solutions specifically targeted at meeting the needs of this segment of society. In the same context, blind people are essentially dependent on the traditional white cane for their mobility, which helps them sense the road and obstacles directly ahead. However, this cane remains a limited tool and is insufficient to meet all their safe mobility needs. Smart canes, which can find surrounding impediments and warn the user, don't make crossing streets completely safe. This shows how important it is to come up with better ways for blind individuals to get around on their own and safely [9].

There have been substantial improvements in technology, especially in small electronic parts, processing power, gaining data in real time [10], and sensing. Intelligent navigation systems have become a possible answer [11]. A growing number of people, including blind people, depend on technology in their daily lives. This makes it possible to use this technology to help blind people see impediments and get the help they need to move about their environment safely and easily [4]. Crossing streets is especially hard for people who can't see, thus coming up with new technical solutions to this problem is a high focus.

Researchers have been working on a number of new projects to help blind individuals as follows:

1- Nazri et al., 2020 [12] talks about a system that helps people with vision problems who have trouble getting around on their own in new places. To do this, they built a smart cane that has an ultrasonic sensor to find obstructions, a water sensor to find puddles, and a GPS device that lets the Blynk application keep track of where the blind person is.
2- Huang et al., 2022 gives a real-world example of how to make and use a Smart and Accessible Pedestrian Signaling System SAPSS that is based on the idea of capability-based design to make sure everyone can use it. The system integrates hardware, software, and a mobile application to provide an enhanced solution for blind people to cross streets comfortably and safely.
3- Yassine Bouteraa, 2023 [13] propose a system that consists of a glasses frame, a hand strap, and an embedded controller based on the Robot Operating System ROS. The developed architecture is equipped with advanced external and internal sensors that provide data on navigation parameters (position, speed, acceleration, and direction) and obstacles (both on the ground and in front of the user). A safety assessment system is implemented using sensor data fusion and fuzzy classification to determine a human safety path.
4- Gari Mauramdha, 2025 [14] discovered a significant concern about the safety of visually impaired and blind people in the UK, with 48% of them feeling unsafe due to the challenges they faced them such as difficulties crossing the road. One thing that the research recommends is to develop mobility aids.
5- Rabbani et al., 2025 [15] proposes an Internet of Things-based system to improve pedestrian safety and comfort in urban areas, especially in developing countries where road accidents cause deaths and injuries. The system proposes the use of a moving pedestrian crossing, or "moving lane," along with sensors to monitor traffic.

This study suggests making a prototype smart system to help blind persons cross intersections safely. This device may be added to smartwatches. It uses a GPS module and connects to a cloud database to find out exactly where the blind person is. This information lets GPS mapping systems in cars, such Google Maps or Waze, find blind persons on the map. If a car is coming up swiftly and the driver doesn't see the blind person, the device makes a warning sound to let the blind person know not to cross. The watch also has a red light that warns anyone nearby who could be blind of a possible danger, so help can be given right away if needed. The goal of this technology is to make cities safer for blind people and help them get around more easily.

There are five parts to this research paper: Section 2 looks at previous studies on the topic, while Section 3 goes into great depth about how the suggested prototype works and how it was designed. In Section 4, the outcomes are talked about and analyzed. Lastly, Section 5 gives conclusions and makes suggestions and recommendations for future research in this area.

2. METHODOLOGY

This section presents the mechanism of action and design of the proposed system. Taking into consideration that the proposed system is a prototype for testing only.

2.1 System Design Analysis

This section will demonstrate the design of the proposed system, using the Unified Modeling Language UML as the main tool for analysis. The first diagram used to analyze the proposed system is a Use Case diagram, which is shown in Figure 1. The system involves two main actors:

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

1- A smartwatch (for the blind user): This determines the user's location, triggers alerts, stores coordinates in a cloud database (Firebase), and receives alerts from the car's application.

2- The application (in the car): This calculates the distance and speed between the car and the blind user (using API), sends alerts when coming nearer, and receives the blind coordinate data from the database.

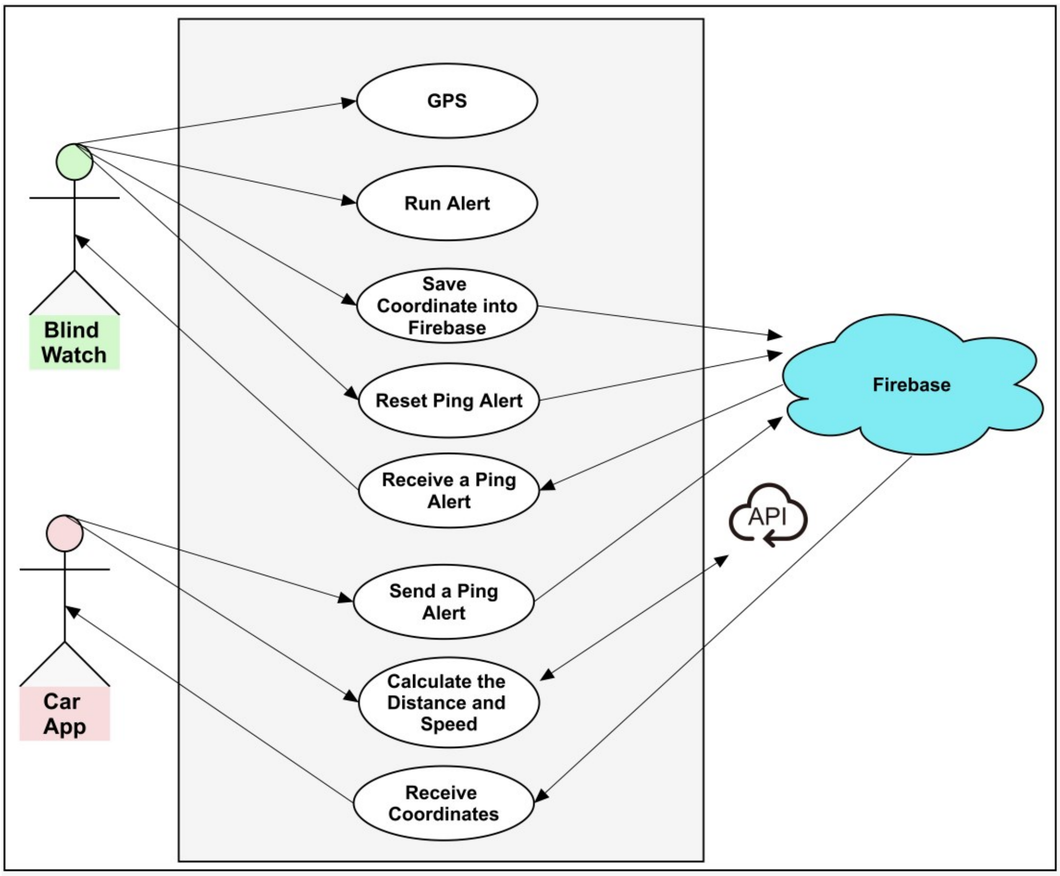

Fig. 1: Use Case diagram for the proposed system

This diagram also depicts how users and the system are connected. The system's functional requirements include the need for GPS to accurately determine location, the need for devices to be able to communicate with each other instantly, the need for a cloud database to transfer data, and the need to send an instant alert to help blind people make safe choices when crossing the street.

The system's scope also includes making sure that blind individuals are safe when they cross the street by sending notifications and smart synchronization. It does not, however, include other areas like traffic control or self-driving cars.

The activity diagram (Figure 2) shows the order in which the system takes steps to make sure the road is safe to cross. It talks about how the wristwatch, Firebase, and automobile application operate together. To begin, turn on the smartwatch, retrieve the coordinates of the blind location, and send them to Firebase. The car application also checks the blind's location in Firebase and works out how long it will take them to get there. This interaction makes sure that the user is warned in time to cross the street safely.

Lastly, the sequence diagram (Figures 3 and 4) shows how the different parts of the system send and receive messages in detail. Starts by the smartwatch (GPS module) requesting for its location and transmitting it to the Firebase cloud database. At the same time, the car application asks the GPS where they are and Firebase for the blind user's coordinates. After that, these coordinates are looked at to figure out how much time is left till the blind user gets there. If the time is less than two minutes, the smartwatch gets an instruction to turn on the alert. This picture

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

shows how important it is for devices to talk to each other in real time so that they can respond quickly and effectively. This makes it safer and easier for blind individuals to cross the street.

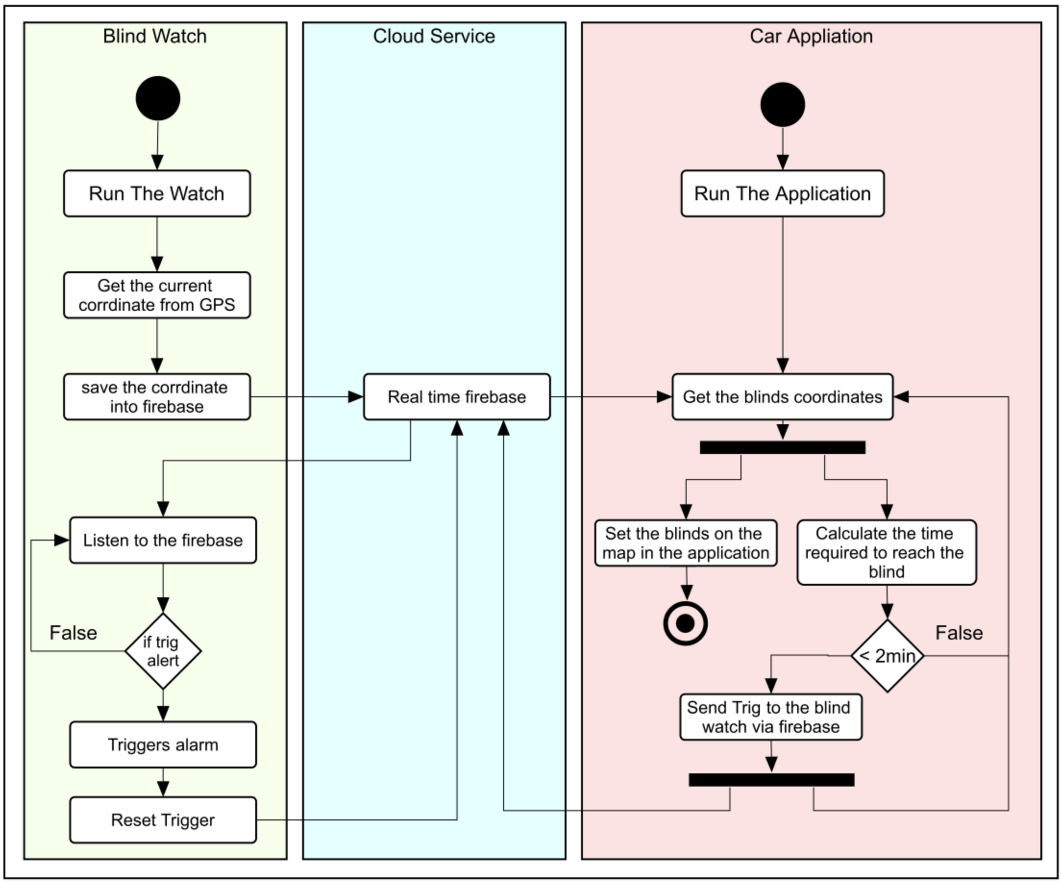

Fig. 2: Activity diagram for the proposed system

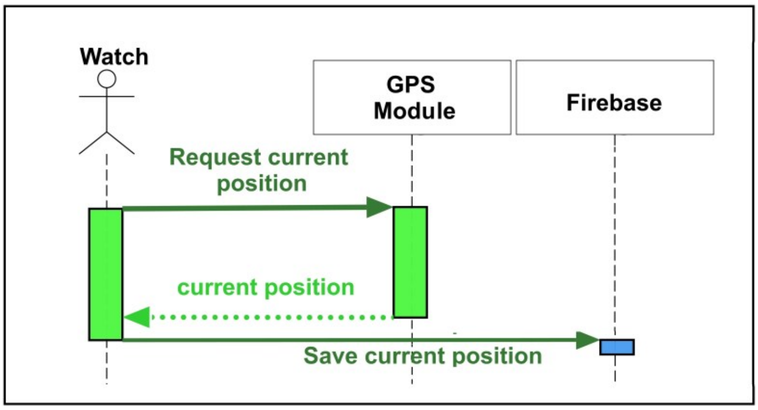

Fig. 3: Sequence diagram for the watch side

2.2 Cloud Database Design

This part shows how the Firebase real-time cloud database is set up to handle location data and alerts in the smart assistance system for the blind. Figure 5 shows what it looks like in JavaScript Object Notation JSON format. The Firebase gives each smartwatch that a blind person uses a unique MAC address. The following information is stored for each entry with a MAC address:

1- AlertCar: A binary value (1 or 0) that tells the wristwatch whether or not to sound an alarm (such a sound or vibration) when a car is coming (1 = alert active, 0 = safe).

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

2- x and y: Represent the blind user's current geographic coordinates, where x is latitude and y is longitude.

This architecture allows the companion application in the car to monitor the location of each blind user in real time. When the vehicle approaches a predetermined distance, the AlertCar value of the corresponding smartwatch is updated, triggering the alert. The smartwatch continuously listens for changes in the AlertCar value and responds immediately by activating or deactivating the alert.

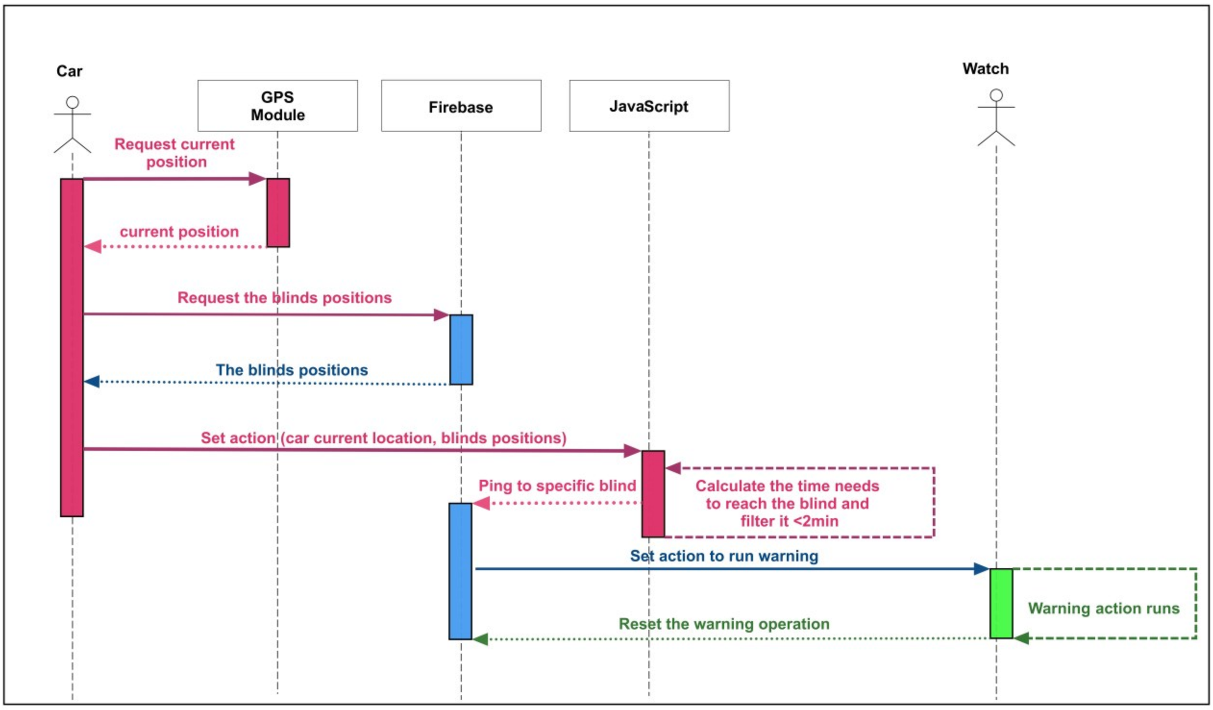

Fig. 4: Sequence diagram for the car side

```
{
 "blinds": {
  "MAC ADDRESS": {  ← String: C8:C9:A3:69:98:F6
   "x": Latitude,       ←Float: 33.3706205
   "y": Longitude,      ←Float: 44.3444329
   "AlertCar": "Binary"  ←Boolean: 1
  }
 }
}
```

Fig. 5: The proposed Firebase real-time cloud database in JSON

2.3 Hardware Requirements for the Prototype Model

This section describes the prototype hardware requirements, focusing on the components used in a smartwatch, which include:

1- NodeMCU ESP8266

2- GPS Module (Neo-6M)

3- Buzzer

4- LED Indicator

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

Figure 6 shows a complete schematic of the hardware connections, highlighting the connections and interactions between the microcontroller, sensors (such as GPS), and actuators (Buzzer and LEDs).

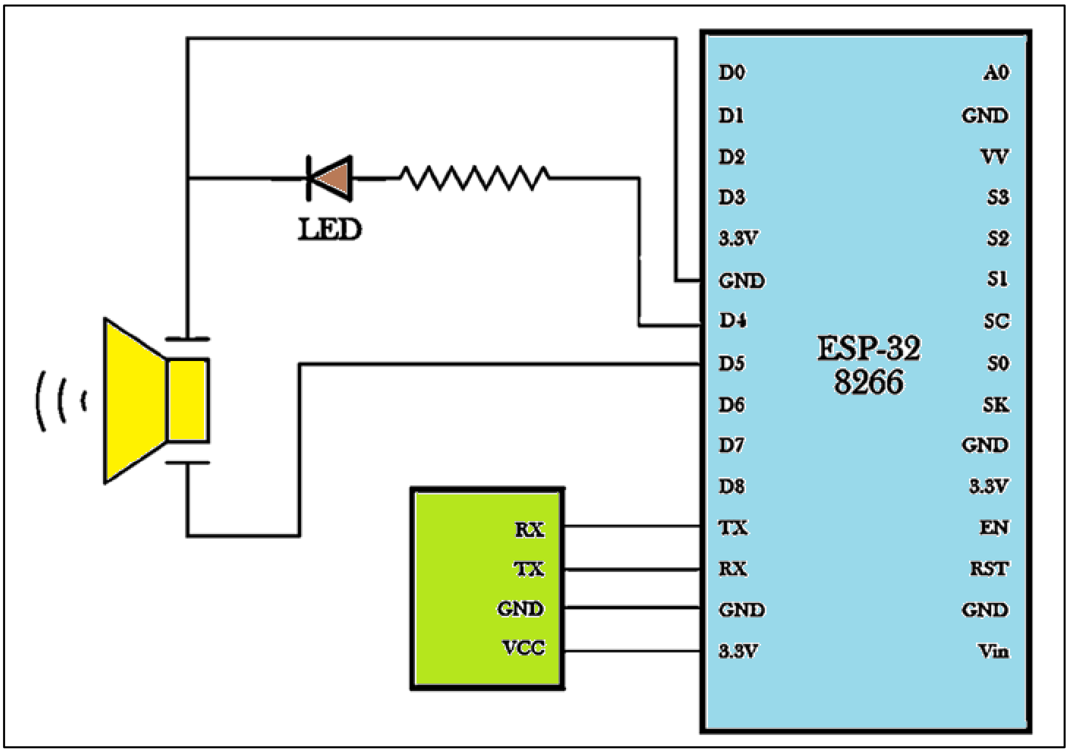

Fig. 6: Hardware requirements scheme for the prototype model

2.4 Software Requirements for the Prototype Model

In this section, the following elements must be included:

1- Programming Languages and Development Tools: To develop this prototype, many programming languages and libraries were used to cover all aspects of the system. To monitor the blind person through the smartwatch, the Arduino environment (C/C++) was used to program the NodeMCU ESP8266 module. This module is responsible for connecting to the internet and the Firebase database, sending location data that is collected via the GPS module to the Firebase real-time database, and it is controlling the activation of alerts (buzzer and lights) after reading the alert status from the Firebase. The web application, which is used by the driver, was designed using HTML, CSS, and JavaScript to run on different browsers (mobile phone or tablet). The application displays a clear map and tracks the locations of blind people in real time. Additionally, JavaScript libraries that are specific to maps (such as Leaflet or the Google Maps API) were used to facilitate the map display and location determination process.

2- Algorithms and Logic: There are two algorithms used to implement this prototype. Algorithm 1 shows the smartwatch side, which is simulated using NodeMCU, while Algorithm 2 shows the application working on the driver's side.

2.5 Proposed Integration

To reduce cost and weight, the proposed prototype system could be embedded within an existing device that is provided on the market. For example, smartwatch manufacturers could add a feature that helps blind people (for example, "blind") to their smartwatches. This will allow sending the geographic location of the blind person who is wearing the watch to a specific cloud database, and the audio system could be used too to alert the blind person by using an alarm clock, as well as the vibration module of the watch. The screen lighting of the watch could also be used to notify people that the person who wears the watch is blind. Similarly, navigation map providers, like Google, Waze, and others, link their applications to the blind database.

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

Algorithm 1 GPS Alert System with Firebase

```
Start
WiFi_Status ← Connect to Wi-Fi using hardcoded SSID and Password
GPS_Module ← Initialize software serial for GPS communication
Loop Forever:
  (Latitude, Longitude) ← Read GPS coordinates from the GPS_Module
  Firebase["x","y"] ← (Latitude, Longitude)
  Alert_Flag ← Firebase["Alert"]
  If Alert_Flag == "1" Then
    Buzzer ← ON
    LED ← ON
    Wait 30 seconds
    Firebase["Alert"] ← "0"
  End If
  Buzzer ← OFF
  LED ← OFF
  Wait 2 seconds
End Loop
End
```

Algorithm 2 Driver-Car Proximity Alert for Blind Users

```
Start
Loop Forever:
  Driver_Location ← Get current coordinates via the Geolocation API
  Speed ← Calculate speed from previous and current positions with times-
tamps
  Blind_Users_List ← Fetch blind users within a 2 km range from Firebase
  Display Blind_Users_List on the map using blue Leaflet markers
  For each Blind_User in Blind_Users_List:
    Distance ← Calculate using the Haversine formula
    ETA ← Estimate based on Distance and Speed
    If ETA ≤ 2 minutes Then
      Firebase["AlertCar"] for Blind_User ← "1"
    End If
  End For
  Wait 1 second
End Loop
End
```

3. RESULTS AND DISCUSSION

In this section, the proposed prototype system was implemented and tested. Figure 7 shows the hardware implementation of all the components simulated for the smartwatch. Figure 8 shows the application interface that is displayed on the mobile of the driver, the red Leaflet markers representing the driver's location on the map, while the blue one represents the blind person's location.

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

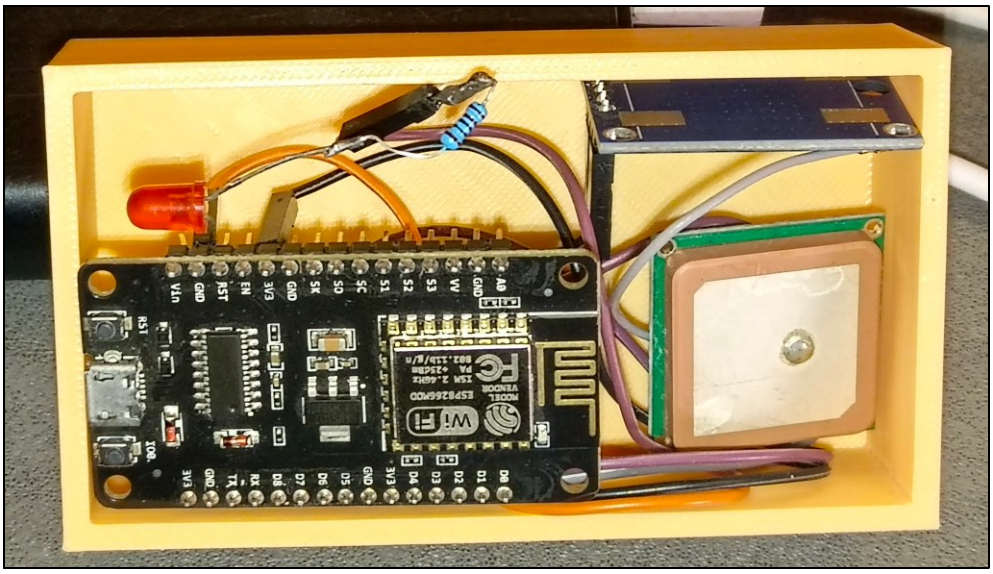

Fig. 7: Hardware implementation for the blind watch prototype

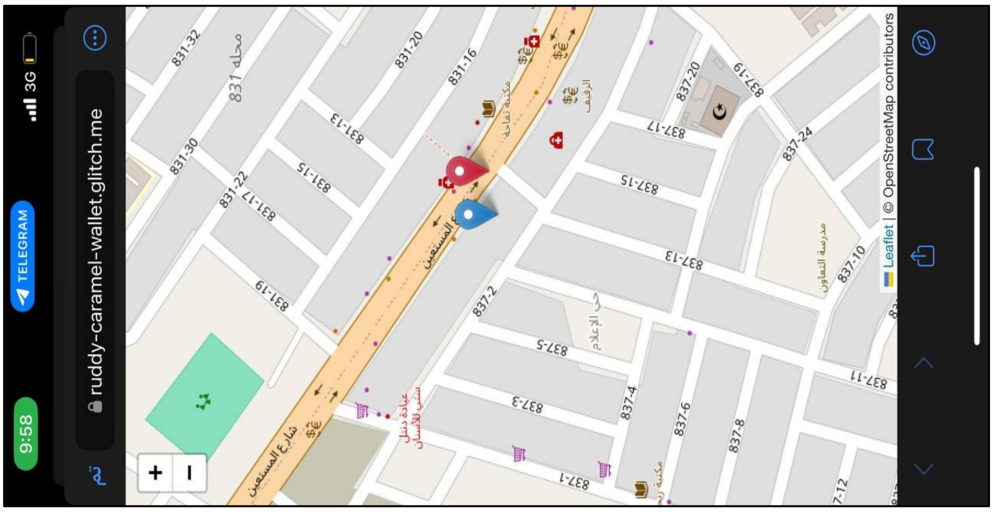

Fig. 8: The application interface for the driver's mobile

The proposed system was tested using three scenarios: scenario 1 with a car speed of 10km/h, scenario 2 with a car speed of 20km/h, and scenario 3 with a car speed of 50km/h. Table I shows the comparison test with these different scenarios. The parameters that are used in the test are:

1- Response Coverage Distance Accuracy: It represents the percentage of the covered distance (2 km) that the device (mobile) can still receive the visually impaired people.

2- Time to Reach Blind Accuracy: It represents the percentage difference in the expected time for the vehicle to reach the visually impaired person compared to the actual time.

3- Response Trigger Distance Accuracy: It is the distance at which a blind person is notified not to cross the street. Its accuracy represents the percentage difference between the expected distance of the car to reach the visually impaired person and the actual distance of its arrival.

4- Average Response Time: It represents the total time required to read the location of a blind person, determine the time required to reach him, and send a signal to him not to cross the street if the time required to reach him is 2 minutes.

5- GPS Accuracy: The Threshold was based on a GPS positioning error with a radius of 7 meters.

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

TABLE I: Scenarios Comparison Test

Scenario No.	Speed (km/h)	Response Coverage Distance Accuracy (%)	Time to Reach Blind Accuracy (%)	Response Trigger Distance Accuracy (%)	Number of Response Readings	Average Response Time (sec)	GPS Accuracy (%)
1	10	99.80	99.44	99.998	58	1.31	98
2	20	99.75	99.17	99.998	60	1.38	98
3	50	99.65	95.83	99.997	59	1.54	96

To evaluate the system's performance, the actual and predicted coverage distances were analyzed, as shown in Figure 9, demonstrating the response unit's ability to provide continuous monitoring throughout the travel. Additionally, the predicted time to reach the blind person was compared with the actual time recorded using the system's timestamps, as shown in Figure 10. The accuracy of the time to reach the blind person was calculated as the percentage deviation between the predicted and actual times, with a concentration on the effect of driving speed on this accuracy. Finally, the system's response initiation timing was examined by comparing the predicted response trigger distance with the actual distance at which the alert system began to operate, as represented in Figure 11.

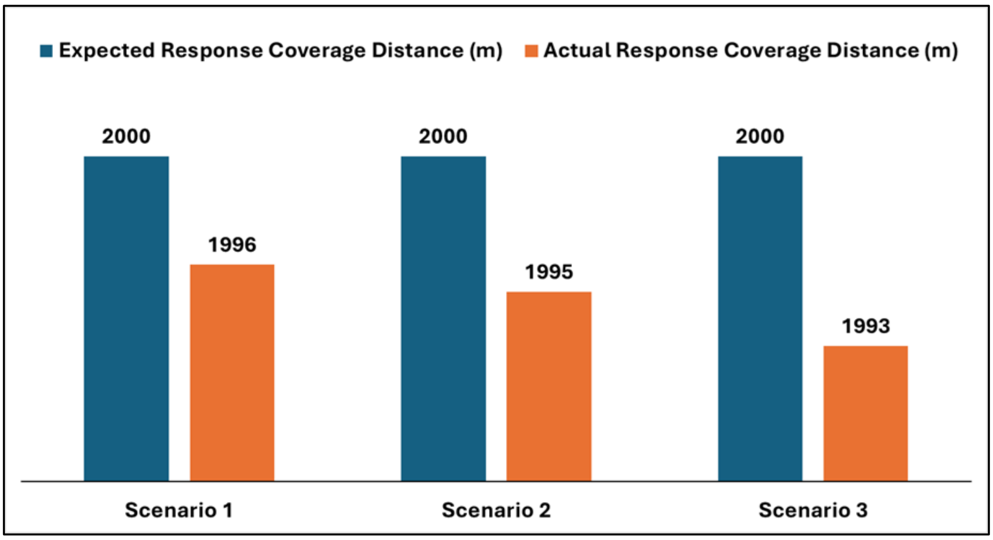

Fig. 9: Coverage Distances Comparison

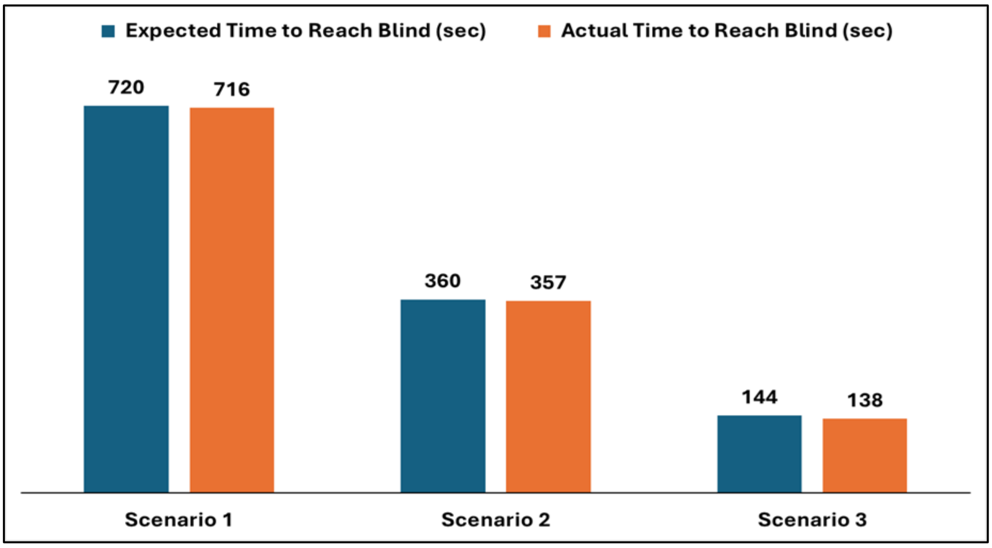

Fig. 10: Time to Reach the Blind Comparison

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

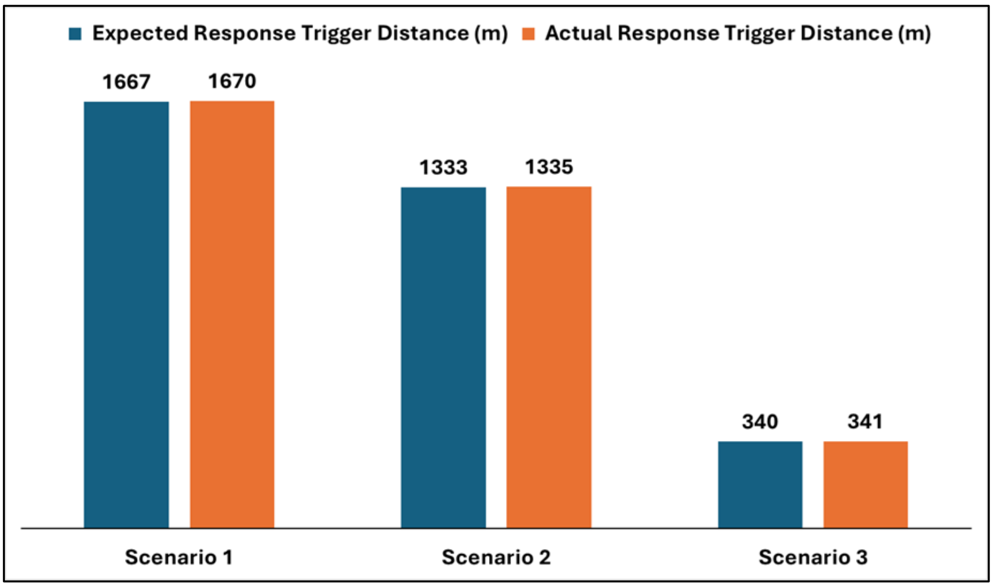

Fig. 11: Response Trigger Distance Comparison

4. CONCLUSION

This research aims to develop and test a smart assistance system for the blind, relying on Internet of Things technologies to provide real-time alerts. Using GPS and dynamic risk assessment, the proposed system demonstrated high accuracy in detecting and reporting potential threats from vehicles. Experimental results demonstrated the system's reliability under varying vehicle speeds. These combined features enhance spatial awareness and improve safety for visually impaired and blind users during their navigation.

For future development, we propose integrating the proposed system into a commercial smartwatch to eliminate reliance on dedicated devices. Furthermore, we recommend adding custom algorithms to detect specific pedestrian crossings and alert users accordingly.

References

[1] K. Xia, X. Li, H. Liu, M. Zhou, and K. Zhu, “IBGS: A wearable smart system to assist visually challenged,” *IEEE Access*, vol. 10, pp. 77810–77825, 2022.

[2] C. G. Mallamma, B. D. Varalakshmi, K. P. Nagapushpa, and U. Anuradha, “Smart Navigation Assistance System for the Visually Impaired,” Jun. 2020.

[3] M. A. Khan, D. M. Z. Khan, S. E. Bazai, S. O. Ahmed, H. Khan, and N. Ejaz, “ullah N (2020) Motion based smart assistant for visually impaired people,” *Indian J Sci Technol*, vol. 13, no. 16, pp. 1612–1618, 2020.

[4] S. Patil, O. Gawande, S. Kumar, and P. Shewale, “Assistant Systems for the Visually Impaired,” *International Research Journal of Engineering and Technology (IRJET)*, vol. 7, no. 1, 2020.

[5] S. Mishra, K. Anand, and N. Z. Jhanjhi, “A Smart Personal Assistant for Visually Challenged,” in *Proceedings of 2nd International Conference on Mathematical Modeling and Computational Science: ICMMCS 2021*, Springer, 2022, pp. 505–515.

Iraqi Journal for Computers and Informatics
University of Information Technology and Communications
Vol. 51, No. 2, 2025, pp. 98-108
DOI: https://doi.org/10.25195/ijci.v51i2.616
Print ISSN: 2313-190X, Online ISSN: 2520-4912

[6] S. D. Karim and A. M. M. Al-Chalabi, “Empowering the Disabled and Elderly: A Voice Control Unit for Assistive Technology,” *Iraqi Journal of Science*, pp. 4828–4836, Sep. 2024, doi: 10.24996/ijs.2024.65.8(SI).15.

[7] M. E. Hossain, K. M. Qaiduzzaman, and M. Rahman, “Sightless helper: an interactive mobile application for blind assistance and safe navigation,” in *Cyber Security and Computer Science: Second EAI International Conference, ICONCS 2020, Dhaka, Bangladesh, February 15-16, 2020, Proceedings 2*, Springer, 2020, pp. 581–592.

[8] S. Martínez-Cruz, L. A. Morales-Hernández, G. I. Pérez-Soto, J. P. Benitez-Rangel, and K. A. Camarillo-Gómez, “An outdoor navigation assistance system for visually impaired people in public transportation,” *IEEE Access*, vol. 9, pp. 130767–130777, 2021.

[9] P. Whig, “IoT based novel smart blind guidance system,” *Journal of Computer Science and Engineering (JCSE)*, vol. 2, no. 2, pp. 80–88, 2021.

[10] S. M. Al-Chalabi, A. M. Al-Chalabi, and R. A. Al-Khafaji, “Innovative pre-fire alert smart detection system-based embedded system,” *AIP Adv*, vol. 14, no. 5, May 2024, doi: 10.1063/5.0195026.

[11] S. Khan, S. Nazir, and H. U. Khan, “Analysis of navigation assistants for blind and visually impaired people: A systematic review,” *IEEE access*, vol. 9, pp. 26712–26734, 2021.

[12] N. M. A. Nazri, S. S. M. Fauzi, R. A. Gining, T. R. Razak, and M. N. F. Jamaluddin, “Smart cane for visually impaired with obstacle, water detection and GPS,” *Int. J. Comput. Digit. Syst*, vol. 10, no. 1, pp. 2–8, 2020.

[13] Y. Bouteraa, “Smart real time wearable navigation support system for BVIP,” *Alexandria Engineering Journal*, vol. 62, pp. 223–235, 2023.

[14] Gari Mauramdha, “Pedestrian Safety for Visually Impaired Pedestrian,” *Journal of Information Systems Engineering and Management*, vol. 10, no. 33s, pp. 289–296, Apr. 2025, doi: 10.52783/jisem.v10i33s.5531.

[15] G. M. Rabbani *et al.*, “Enhancing Pedestrian Safety and Urban Mobility through IoT-Based Smart Pedestrian Crossings,” in *2025 International Conference on Electrical, Computer and Communication Engineering (ECCE)*, IEEE, Feb. 2025, pp. 1–6. doi: 10.1109/ECCE64574.2025. 11013514.