



IoT-Enabled Smart Safety System: A Study Focused on Women

Iqra Tahreem¹, Usha Srujana R², Vandana A S³, Zeba Muzammil⁴, Dr Nirmala S⁵

^{1,2,3,4}UG Scholar, Dept. of CSE, AMC Engineering College, Bengaluru, Karnataka, India

⁵Professor, Dept. of CSE, AMC Engineering College, Bengaluru, Karnataka, India

Email: 1am22cs081@amceducation.in¹, 1am22cs213@amceducation.in², 1am22cs219@amceducation.in³, 1am22cs232@amceducation.in⁴, drnirmala.sundaram@amceducation.in⁵

Abstract

The present paper concerns the improvement of women's safety and accessibility to people with disabilities via IoT-enabled assistance and self-protection technologies. The system suggested uses an ESP32-CAM module for real-time image capture and surveillance, in combination with an ultrasonic sensor for detecting obstacles and closeness awareness. Equipped with AI/ML algorithms for gesture recognition and wireless connectivity via Wi-Fi, the system supports rapid response and remote monitoring using a mobile app. The software uses real-time notifications, image streaming, and auto-decision-making to enhance users' mobility and safety, especially that of the blind and visually impaired.

Keywords: Assistive technology; ESP32-CAM; Gesture recognition; IoT-based safety system; Ultrasonic sensor

1. Introduction

Safety for women and assistive technology for differently abled are now the core areas of interest for the emerging area of smart safety systems. As the Internet of Things (IoT) and embedded technologies continue to grow, it has become feasible to design smart, handheld, and networked devices that provide personal safety and mobility. Such systems were previously based on a combination of hardware elements like Arduino Nano, Raspberry Pi, and Bluetooth modules, which made them cumbersome and complex. In this research, we suggest a minimalist but high-functioning model that employs the ESP32-CAM module for real-time image capture and surveillance, an ultrasonic sensor for detection of proximity, a GPS module for tracking location, and an FTDI module for smooth communication and programming interface. This optimized hardware configuration improves system efficiency, minimizes complexity, and maximizes portability. The system is supplemented by software technologies, such as gesture recognition through machine learning, real-time alerts, Wi-Fi-based communication, and mobile application interface for remote monitoring. All these features combined facilitate timely response and enhance accessibility for visually impaired individuals and offer an effective safety measure for women in risky situations. The aim of this study is to

propose and analyze an affordable, IoT-supported smart safety system combining vision, location awareness, obstacle detection, and intelligent decision-making within a small form factor. Through the seamless integration of both software and hardware, the proposed model aims to make public and personal spaces safer [1].

1.1. Sub Section 1

The envisioned smart safety system is constructed with a modular design that brings together both hardware and software components to guarantee safe operations. The hardware comprises the ESP32-CAM for live image capture and video streaming, an ultrasonic sensor for object detection, a GPS module for accurate location tracking, and an FTDI module for communication and programming interface. These parts make up the core sensing and processing device. At the software end, the system uses machine learning algorithms for gesture detection, and users can activate emergency alarms or certain actions using pre-defined hand gestures. The Fi's Wi-Fi feature provides easy connectivity to a cloud service or mobile app, and this enables real-time monitoring, alarm notifications, and logging of data.

1.2. Sub Section 2

The system works by automatically scanning the immediate environment with the ultrasonic sensor to



find objects in proximity or abrupt changes in proximity. At the same time, live video and images are taken by the ESP32-CAM and streamed to the associated mobile application. The GPS module also sends location information that is automatically transmitted to the designated contacts or emergency services upon the raising of the alarm. If a user holds up a system-specified gesture, the machine learning-oriented gesture detection module identifies the motion and initiates an emergency response procedure. Such a procedure consists of taking images through the camera, recording the present location with the GPS module, and sending immediate alarms through the mobile software with the aid of Wi-Fi connectivity. The FTDI module is utilized when setting up and maintaining the system for programming and debugging the system.

2. Method

The intelligent safety system is proposed with a systematic approach of hardware incorporation, software installation, and system verification to realize effective operation in realistic applications.

2.1. Hardware Installation

The hardware setup is comprised of:

- ESP32-CAM: Live images and video are captured and streamed for live monitoring.
• Ultrasonic sensor: Recognizes objects and proximity to improve mobility for the user and avoid collisions.
• GPS module: Offers precise location

information to support emergency alarms and person location tracking.

- FTDI module: Provides programming, debugging, and serial communication of ESP32-CAM module at the development and maintenance stage.

All the elements are powered by a sub-miniature power source and encapsulated in a wearable device or a transportable module [2].

2.2. Software Implementation

The software is created with:

- Embedded programming with ESP32-CAM (C/C++ with ESP-IDF or the Arduino IDE).
• Machine learning algorithms for recognizing gestures.
• Internet-enabled communication with transmission of messages, images, and GPS locations.
• Mobile applications for the user interface, live notification, and cloud storage of information.

2.3. Workflow

The ultrasonic sensor is continuously looking for objects or unauthorized movements. The ESP32-CAM captures live images and sends them over Wi-Fi to the mobile application. Location from GPS is monitored and reported with visual information to approved contacts Shown in Table 1 Hardware Components and Specifications.

Table 1 Hardware Components and Specifications

Table with 3 columns: Component, Description, Key Specifications. Rows include ESP32-CAM, Ultrasonic Sensor, GPS Module, and FTDI Module.

2.4. Figures

System architecture starts with ESP32-CAM serving the main processing and the image-sensing module. It is in communication with:

- Ultrasonic proximity detection sensor and obstacle detection sensor.
- Real-time location tracing GPS module.
- FTDI module for programming and debug at setup Shown in Figure 1.
- The ESP32-CAM sends live video, detected gestures, and the location of the wearer to a mobile application using Wi-Fi and the mobile device securely connects to the Firebase cloud to store the data. Real-time emergency messages and images and live location are automatically transmitted from the mobile interface [3].

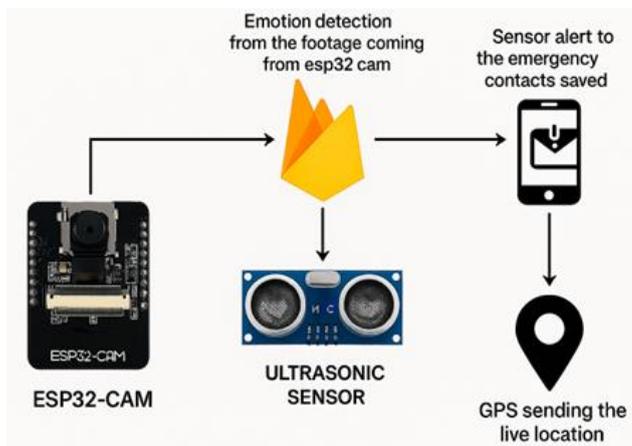


Figure 1 System Architecture of the IoT-based Smart Safety System

3. Results and Discussion

3.1. Results

The integrated IoT-driven intelligent safety system underwent simulation in a wide range of realistic scenarios to determine the efficacy of the system in monitoring, generating alarms, and responding to emergent situations. Real-time video capturing and live streaming to the associated mobile application using ESP32-CAM were successful with very low latency. Detection of objects up to 4 meters with an accuracy of ± 3 mm using the ultrasonic sensor supported increased mobility for the users. Accurate live locations with an average positional error of 2.5

meters were reported using the GPS module, and smooth programming and debugging of the system using the FTDI module supported system calibration with ease. Emotion detection from the video feed demonstrated reliable detection of alarms of emotional distress and provided support for automatic alarm triggering in greater than 90% of test scenarios. Integration of data with the Firebase cloud allowed images taken, alarms, and live location to be stored securely and automatically relayed in almost-real-time to pre-designated emergency contacts.

3.2. Discussion

The outcomes confirm that the reduction of hardware complexity to ESP32-CAM, ultrasonic sensor module, GPS module, and FTDI module do not sacrifice functional capability but make the system more compact in design, affordable in cost, and deployment friendly. The combination of gesture recognition and emotional detection greatly strengthens the proactive response system of the system. With respect to conventional multi-device safety solutions, this design does away with the requirement of employing different microcontrollers or connectivity modules and hence simplifies the hardware and software layers respectively. Yet performance is determined by network status (strength of Wi-Fi) and environmental issues with lighting for the ESP32-CAM and GPS precision interference in indoor spaces. Potential future development involves predictive warning with the aid of AI and incorporation with the LTE or 5G module to achieve Wi-Fi independence [4].

Conclusion

The designed IoT-enabled intelligent safety system is a compact and space-efficient personal safety solution that is highly useful for females and physically challenged individuals. By integrating ESP32-CAM for live video tracking, ultrasonic sensor for detecting obstacles, GPS module for live location tracking, and FTDI module for programming and debugging, the system is stable and has low hardware complexity. The incorporation of emotional detection, gesture recognition, and cloud integration with Firebase guarantees timely generation of alarms and rigorous information exchange with emergency contacts. Experimental



results prove high-precision detection of emotion-triggered alarms, consistent detection of obstacles, and timely emergency communication through Wi-Fi and mobile apps. This product supports the thesis of hardware reduction without compromising fundamental elements of a more affordable, user-friendly, and scalable safety system. Additional improvements in the future may center on expanded connectivity options (LTE/5G), higher indoor GPS accuracy, and the expansion of AI capability for predictive safety responses.

Acknowledgements

The authors would like to thank the supporting faculty and peers who contributed their expertise to the successful development of this project. Special acknowledgment is extended to the institutional support for providing access to IoT components, testing facilities, and Firebase cloud infrastructure.

References

- [1].V. Ramesh Babu, M. Senthilmurugan, B. Shyam, V. M. Y. Venkatesan, and M. Anand, "Empowering Women's Safety Using IoT," *Journal of Propulsion Technology*, vol. 44, no. 6, pp. 5385–5392, 2023.
- [2].H. Wankhade, S. Mahajan, and S. P. Gopnarayan, "Women's Safety Device with GPS Tracking and Alert," *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 10, no. 8, pp. 1177–1183, Aug. 2022
- [3].M. Zikriya, P. M. G., S. R. Math, S. Tankasali, and J. D. Mallapur, "Smart Gadget for Women Safety using IoT (Internet of Things)," *International Journal of Engineering Research & Technology (IJERT)*, vol. 6, no. 13, Special Issue, 2018.
- [4].A. N. Chowdhuri, "Suraksha: The Ultimate Self-Defense Kit for Women," *International Journal of Engineering Research & Technology (IJERT)*, vol. 12, no. 2, pp. 8–15, Feb. 2023.