IoT Based Face Recognition Using Machine Learning for Women Safety

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Abstract— Despite two decades of attention to stalking in developed countries, the issue remains understudied in India, where violence against women is higher. Few reported cases receive little notice, but victims face significant financial, social, and mental losses. Research indicates stalking often precedes sexual offenses and murder, highlighting the potential to reduce overall violence against women by preventing stalking at its early stages. In this paper we have implemented women safety system on Raspberry pi via Ultrasonic sensor and Pi camera. The usage of earlier systems in daily life was both expensive and time-consuming. The voice alert safety system (subject) used by a women is described in this study. This system recognises humans using an ultrasonic sensor network. It accurately calculates the separation between the user and other human come in danger zone (distance measure 20 cm from device) or out of danger zone (distance measure more than 20 cm). It identified humans come in danger zone and give verbal feedback to let the user know. Such voice messages are delivered to the subject using the speaker. It also uses camera and facial recognition algorithms to detect faces and recognize the person and inform the user through audio output. The intention of this research work is to create a cheap, portable voice alert safety system for women's.

Keywords- Artificial Intelligence (AI); Internet Of Things (IoTs); Wearable Device; Face Recognition; Women's Safety

1. INTRODUCTION

Women's safety remains a paramount concern globally, with stalking often serving as a precursor to more severe forms of violence. The safety of women is a major concern because they often feel unsafe going out due to the risk of physical or sexual abuse. Despite the advancements in technology, women and girls still face challenges [1]. Women can't freely walk at night in quiet areas, and even during the day in busy locations, many women experience incidents of physical or sexual assault. Unfortunately, rape is becoming one of the most rapidly increasing crimes in the country. Addressing this issue requires innovative and proactive approaches. This research article proposes the development of a smart IoT-based facial recognition system utilizing Raspberry Pi and machine learning techniques [2]. The system aims to detect potential stalkers in real-time, providing immediate alerts to women and relevant authorities. This article outlines the design, implementation, and evaluation of the proposed system, addressing issues such as accuracy, real-time detection, privacy, and user-friendliness. The study investigates how machine learning models can be integrated for Raspberry , ensuring efficiency in constrained computational environments. The study also delves into the adaptability of the system to diverse environments and its potential impact on controlling violence against women [3]. The findings contribute valuable insights into leveraging IoT and machine learning for enhancing women's safety, offering a tangible solution to combat stalking and mitigate the broader issue of violence against women [4].

The primary aim of this exploration work is to implemented women safety system on Raspberry pi via Ultrasonic sensor and Pi camera. The usage of earlier systems in daily life was both expensive and time-consuming. The voice alert safety system (subject) used by a women is described in this study [5]. This system recognises humans using an ultrasonic sensor network. It accurately calculates the separation between the user and other human come in danger zone or out of danger zone. It identified humans come in danger zone and give verbal feedback to let the user know. Such voice messages are delivered to the subject using the speaker [6]. It also uses camera and facial recognition algorithms to detect faces and recognize the person and inform the user through audio output. The intention of this research work is to create a cheap, portable voice alert safety system for women's [7].

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LITERATURE REVIEW

Table 1. Literature Review

Reference No	Authors	Method Used	Research Findings	Research Gap
[8]	Shubhangi et al.	The study proposes an Iot-based Women Safety Night Patrolling Robot. The robot incorporates features like sound sensing, obstacle detection, GPS tracking, night vision cameras, and autonomous movement. It uses an Arduino microcontroller to coordinate its functions. The system can transmit live video and location data to a user's device. It is designed to patrol assigned areas with minimal human intervention.	The robot can effectively patrol areas and detect sounds/obstacles in its environment. It provides real-time monitoring capabilities through live video streaming. The system can track its own location and share it with users. It offers night vision capabilities for low-light conditions. The robot can be controlled remotely via a smartphone app. It demonstrates potential for enhancing women's safety in various environments	The paper does not provide extensive quantitative data on the robot's performance. Long-term testing in real-world conditions is not discussed. The system's effectiveness compared to existing security measures is not analyzed. Potential limitations or challenges in widespread implementation are not explored in depth. The paper does not address potential privacy concerns related to constant video monitoring. Cost-effectiveness and scalability of the system are not thoroughly evaluated.
[9]	Chikhale et al.	The study proposes an IoT-based emergency button for women's safety. The system consists of a wearable device with a panic button, GPS, and GSM modules. When the button is pressed, the device sends a distress signal to a predefined list of contacts and authorities. The system uses a microcontroller to coordinate its functions. The gadget is battery-operated and rechargeable using a USB connector.	The system can quickly and accurately send distress signals to emergency contacts and authorities. The GPS module enables location tracking and sharing with emergency responders. The wearable device is compact and user-friendly. The system can be integrated with existing emergency response systems.	The system may not have coverage in all areas, particularly in rural or remote locations. The system requires internet connectivity to function, which may not always be available. The system may not be customizable to meet the specific needs of individual users. The system may be expensive to implement and maintain, making it inaccessible to some users. The system may not be integrated with existing emergency response systems, which could limit its effectiveness.
[10]	Kodieswari et al.	Device Design: Integrated into a handbag with sensors (heartbeat monitoring, fingerprint scanner, burglar alarm). Bluetooth Connectivity: Utilizes HC-05 module for communication between the handbag and mobile phone, enabling message transmission and location tracking without internet. Mobile Mesh Networking: Enables device-to-device communication for message relaying over greater distances without internet access. Android Application: Developed for registering emergency contacts, tracking location, and sending alerts. Emergency Activation: Activated by pressing a button, sending alerts to pre-registered contacts and police with the victim's location.	Increased Safety: Enhances women's safety by providing a reliable alert system in emergencies. Health Monitoring: Integrates heartbeat sensor for health monitoring, alerting contacts in medical emergencies. Offline Functionality: Operates without internet, effective in rural areas with limited connectivity. User -Friendly Design: Practical design allows easy activation and use in emergencies. Community Impact: Potential to significantly improve women's safety and health monitoring, especially in high-risk areas.	Limited Testing and Validation: Lack of extensive empirical testing or validation in real-world scenarios. Scalability and Production: No discussion on scalability for mass production and distribution. Integration with Existing Systems: Lack of exploration on integration with emergency response systems or law enforcement protocols. User Feedback and Iteration: Minimal information on user feedback or iterative design processes for improvements based on user experiences. Broader Health Monitoring Features: Future work could explore additional health monitoring features for comprehensive health assessment.
[11]	Thamaraiselvi et al.	System Design: Design of a smart band system with multiple sensors and programmable hardware. Simulation: Simulation of the smart band system to test its functionality and performance. Prototype Development: Development of a prototype of the smart band system. Testing and Evaluation: Testing and evaluation of the smart band system to identify its effectiveness and limitations.	The smart band system is effective in detecting abnormal situations and sending alerts to the nearest police station and contacts. The sensors used in the smart band system are accurate in detecting physiological signs such as temperature, pulse rate, and motion. The GSM modem used in the smart band system is efficient in sending alert messages to the nearest police station and contacts. The smart band system is 100% resistant to water. Bluetooth 5.0 used	The smart band system has limited functionality and does not include features such as image capturing and video recording. The smart band system does not integrate with other smart gadgets such as identification cards, bangles, watches, glasses, and shoes. The smart band system may not be scalable to a large number of users and may require significant infrastructure and resources to implement. The smart band system does not provide user feedback and may not be user-friendly for all users. The smart band system may

			in the smart band system provides enhanced security and privacy.	not include advanced security measures such as encryption and secure data storage.

3. SYSTEM ARCHITECTURE

3.1. Hardware Components

3.1.1. Raspberry Pi:

For our research work, we used Raspberry Pi 3 as shown in Figure 1**.** The Raspberry Pi 3 was a popular choice among hobbyists, educators, and developers due to its affordable price and versatility. The Raspberry Pi Foundation in the United Kingdom is the developer of the Raspberry Pi line of single board computers (SBCs) [12]. The boards for the Raspberry Pi are made to be low-cost, modularity, open design, credit card-sized computers that provide a platform for learning programming, electronics, and computing. Due to low cost, it is widely used in many areas. There are three series of Raspberry Pi have been released named as Raspberry Pi Zero, Raspberry Pi SBCs and Raspberry Pi Pico [13].

Figure 1. Raspberry pi

3.1.2. Ultrasonic Sensor:

An ultrasonic sensor is an electronic device that uses sound waves at frequencies above the range of human hearing (typically above 20 kHz) to measure distances and detect objects. An ultrasonic sensor consists of two main components: a transmitter and a receiver. It operates on the basis of echolocation, which is how bats find their way around and identify impediments [14], [15]. Ultrasonic sensor measures the distance by emitting ultrasound waves and converting the reflected sound waves into electrical signals. It's important to note that the performance and accuracy of ultrasonic sensors can be influenced by environmental factors such as temperature, humidity, and the nature of the objects being detected (e.g., shape, material, surface properties) as shown in Figure 2.

3.1.3. Raspberry Pi Camera:

Figure 2. Ultrasonic sensor

The Raspberry Pi Camera is a specialized camera module crafted to seamlessly integrate with Raspberry Pi single-board computers. Its purpose is to offer a simple and budget-friendly means of capturing images and videos directly through a Raspberry Pi. This enhances the Raspberry Pi's functionality, making it more versatile for projects that require image capture and computer vision applications. The Raspberry Pi Camera module offers a convenient and cost-effective way to add imaging capabilities to Raspberry Pi projects. With its integration with the Raspberry Pi ecosystem, it provides easy access to image and video capture functionalities, allowing users to explore a wide range of applications involving visual data [16] as shown in Figure 3.

3.1.4. Eyeglass:

We used a simple eyeglass with broad side frame, so that raspberry pi can be attached to it. All the tools like raspberry pi, camera, ultrasonic sensor are attached to it [17] as shown in Figure 4.

Figure 4. Eyeglass

Figure 5. Wires

3.1.5. Connecting wires:

Wires are used to connect all the components together as [18] shown in Figure 5.

3.1.6. Battery:

Battery is used to power the raspberry pi as shown in Figure 6.

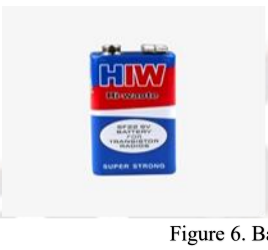

Figure 6. Battery Figure 7. Headphones

3.1.7. Earphone:

Earphone is used to give audio output. These are attached to the aux port of raspberry pi [19] as shown in Figure 7.

3.2. Software Components

3.2.1. Python:

Python is a sophisticated programming language that is interpreted and renowned for its simplicity, adaptability, and readability.

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3.2.2. OpenCV:

OpenCV (stands for Open-Source Computer Vision Library), is a cross platform software library for computer vision and machine learning that is free and open-source under the Apache Licence. For problems involving computer vision and image and video processing, it offers a large number of tools, techniques, Figure 10. Identifying faces Its versatility, performance, and ease of use make it a go-to choice for many computer vision and image processing projects [21].

3.2.3. Face Recognition:

We used face-recognition module of python for facial-recognition. This system employs Figure 3. Raspberry Pi Camera ion technology powered by dlib, utilizing deep learning techniques. The model boasts an impressive accuracy rate of 99.38% based on assessments against the Labelled Faces in the Wild benchmark. In simpler terms, it's a highly reliable tool for recognizing faces with exceptional precision [22].

3.2.3.1. Find faces in pictures:

Locating faces in pictures involves the initial step of identifying and pinpointing all the faces present in an image as shown in Figure 8.

Figure 8. Extracting faces

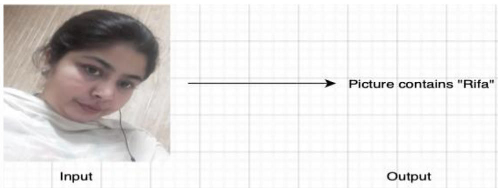
3.2.3.2. Find and manipulate facial features in pictures:

After locating the faces in the pictures, the next step is to identify and outline specific facial features such as the mouth, eyes, nose, and chin for each individual. This involves precisely determining the positions and contours of these key facial elements. These are the important facial features which are useful [23]. But you can also use for really stupid stuff like applying digital make-up as shown in Figure 9.

3.3.3.3. Identify faces in pictures:

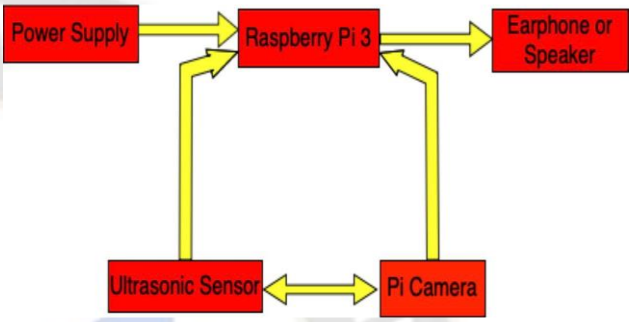
Recognize whose face is appears in each photo as shown in Figure 10.

Figure 9. features Extracting



3.2.4. eSpeak

eSpeak is a compact open- source text-to-speech



(TTS) synthesis engine that converts written text into spoken words. It's available for various platforms, including Windows, Linux, and macOS [24]. It's important to note that eSpeak, while functional and versatile, might not produce the same level of naturalness and quality as more advanced and modern commercial text-to-speech engines. However, its simplicity and customization options make it a popular choice for certain applications, especially those where resource constraints are a consideration [25].

4. PROPOSED SYSTEM

Connections are made by connecting power supply, earphone, ultrasonic sensor and camera from raspberry pi [26] as shown in Figure 11.

4.1. Connect Ultrasonic sensor to Raspberry pi

Ultrasonic sensor is connected to the raspberry pi in the following way as shown in Figure 12:

Trig: 21 GPIO pin (40^{th} Pin)
Echo: 20 GPIO pin (38^{th} Pin)
VCC: 5V PWR Pin (4^{th} Pin)
GND: GND Pin (6^{th} Pin)

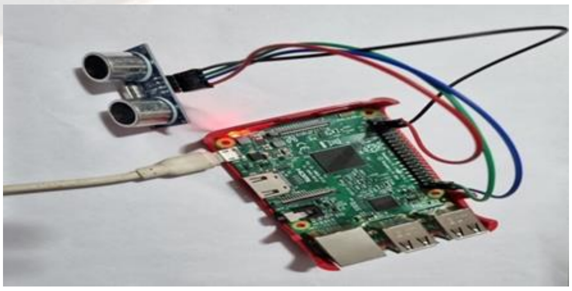


Figure 11. Block Diagram of Connection

4.2. Connect Raspberry Pi Camera to Raspberry pi

Raspberry pi is connected to the camera port given on the raspberry pi as shown in Figure 13. It captures images and pass it to our model to recognize the person.

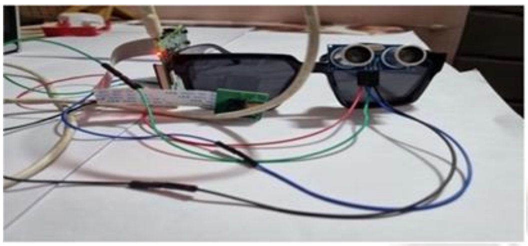


Figure 12. Ultrasonic sensor connected to Raspberry Pi

4.3. Full Connection

All testing individual component, we combined both so that they can work together as shown in Figure 14.

Figure 13. Camera connected to Raspberry Pi

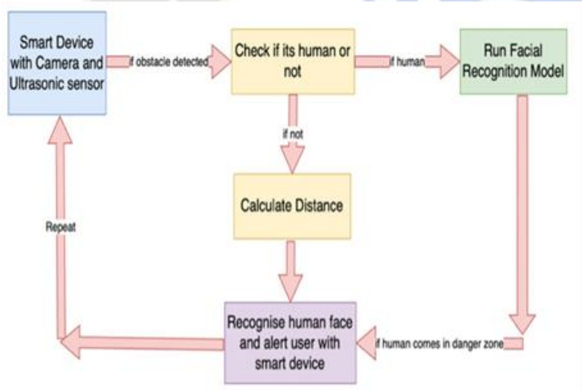


Figure 14. Full connection on Eyeglass

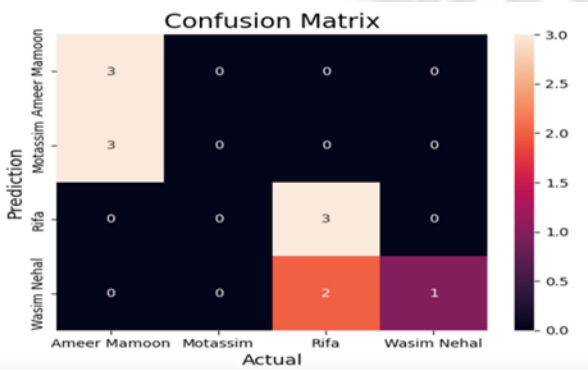


Figure 15. Work Flow of model

Ultrasonic sensor and camera module continuously tries to detect objects comes danger zone" or "out of danger zone".

Once, an object is detected, then ultrasonic sensor calculates its distance. If it is "in danger zone" then, camera checks, if it's a human or not. If it's a human and comes in danger zone, then it tries to match face with already saved faces. If a match if found, then it speaks name of the person using espeak module. If no match for the person is found, then it speaks unknown person. This process keeps on repeating.

4.4. Model Trained

In this paper, the models have to trained using VGG16 model on dataset which was created by taking the original images of people including me and my friends from different angles using mobile phone. Each person have 5-10 images, that were not enough, so augmentation technique was applied to each photo creating large number of images. Around 240 images were collected after augmentation for dataset, each person having around 40-50 photos after augmentation. We took lists named as images for storing images and Labels to store the names of each image. Then, the dataset was split into 20% for testing data and 80% for training data, as image_train, image_test, label_train and label_test. The device is trained using VGG16 model having multiple layers with 10 epochs so that it can give good accuracy. After training testing is perform by gave an image to model for prediction it will tell the probabilities for belonging in each class. The class having highest probability is the class in which the given images belong Figure 16. Shows my images in dataset.

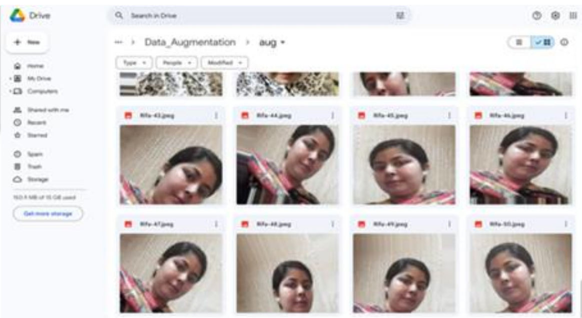


Figure 16. My images in dataset before applying augmentation

After applying augmentation on each image, we get more images in dataset as shown in Figure 17.

After training the model we get accuracy graph and loss graph as shown in Figure 18. and Figure 19. Respectively. Confusion matrix is shown in Figure 20.

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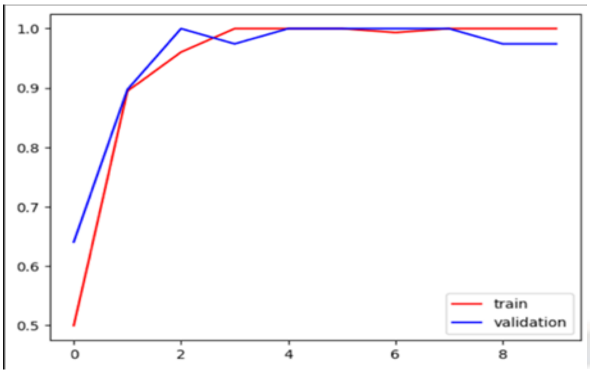

Figure 17. My images in dataset after applying augmentation

Figure 18. Accuracy Graph

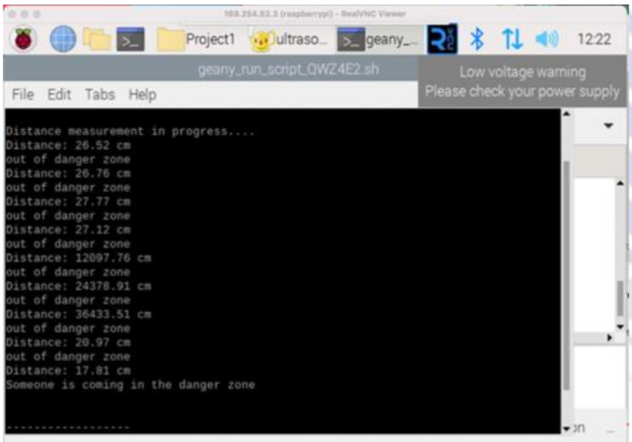

Fig. 19. Loss Graph

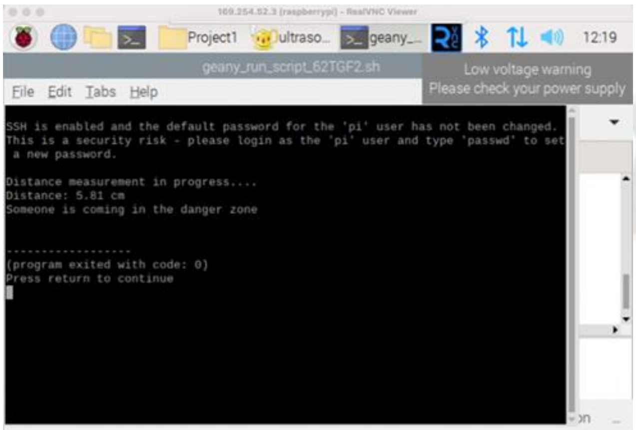

Figure 20. Confusion Matrix

RESULT

This research model is working fine for human face detection. It detects and recognize any human when it is come in contact with ultrasonic sensor whether it is known or unknown. It calculates distance accurately in centimeters and show message "out of danger zone" for distance more than 20 cm as shown in Figure 21 or "Someone is coming in danger zone" for distance less than 20 cm as shown in Figure 22.

When any human comes in less than 20 cm than it is also able to detect humans face and recognize them with an accuracy of more than 90%. It gives correct audio output with person name if it is already saved in database and say unknown if it not in database.

5. CONCLUSION

In this research work a low-cost, portable wearable device for women's safety was developed by leveraging Internet of Things (IoT) and machine learning technologies. The system employs a dual-layer detection mechanism that integrates ultrasonic proximity sensing with real-time facial recognition, implemented on a Raspberry Pi platform. To enhance user awareness, audio feedback was incorporated to notify individuals about the presence of known or unknown persons entering a predefined "danger zone" within a 20 cm distance.

A custom VGG16-based face recognition model was designed and trained, specifically optimized for deployment on low-resource devices, achieving over 90% recognition accuracy during real-world testing.

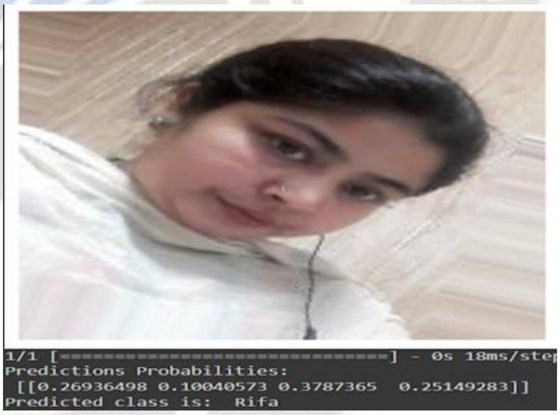

Figure 23. Testing perform which shows name of person with highest class probability

The proposed solution also ensures reliable operation without the need for continuous internet connectivity, making it suitable for deployment in rural or poorly connected environments. While the prototype demonstrates promising results in terms of accurate face recognition and distance measurement, certain limitations were identified. These include the need for higher-range sensors, multi-angle detection capabilities, and low-light imaging enhancements, which are recommended as directions for future improvement.

Fig. 24. Testing perform which shows name of person with highest class probability

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