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IOT BASED LIGHT COMPREHENSIVE WEARABLE SAFETY SYSTEM WITH FALL DETECTION AND VOICE-ACTIVATED IMAGE CAPTURE FOR EMERGENCY RESPONSE

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Abstract

This research presents a thorough wearable safety system that consists of a bracelet and chain that are integrated with the BYOB mobile application. The bracelet, which is furnished with an MPU6050 sensor and ESP32 microcontroller, is specifically engineered for fall detection. It activates alerts to emergency contacts that are saved within the application. The chain, constructed with an ESP32-CAM board, MAX microphone, and NeoGPS, reacts to voice commands defined by the user. This prompts image capture and real-time GPS sharing. The BYOB application offers a user-friendly interface for overseeing emergency contact information, personal data, and customization of voice commands.

Keywords: Wearable Safety System, Bracelet, Chain, BYOB Mobile Application, MPU6050 Sensor, ESP32 Microcontroller, Fall Detection, Emergency Alerts.

I. INTRODUCTION

Fall detection and security problems, such as kidnapping, are major obstacles that affect people's safety and well- being, especially vulnerable populations like the elderly and those with mobility issues. Falls can cause a wide range of injuries, from small bruises to severe trauma, emphasizing the significance of early identification for appropriate intervention and medical care. Similarly, kidnapping carries enormous risks to victims, including bodily pain, psychological suffering, and even death.

Traditional approaches to these concerns have depended on manual surveillance, wearable sensors for fall detection, and law enforcement operations to prevent kidnappings. However, new technological breakthroughs promise more effective treatments. Our research study describes a wearable safety device that combines cutting-edge technology to address both fall detection and security concerns. This research paper proposes an innovative solution to two crucial issues affecting individuals' safety and well- being: fall detection and security concerns, notably kidnapping. Falls, which are often the result of accidents or medical emergencies, pose considerable risks, especially to the elderly and people with mobility challenges. Kidnapping instances, on the other hand, pose a threat of bodily harm, psychological anguish, and even death, needing proactive prevention and response measures.

The bracelet utilizes advanced sensors for automatic fall detection, triggering alerts to emergency contacts for timely assistance. Simultaneously, the chain responds to user-defined voice commands stored within the app, facilitating real-time image capture and GPS tracking in potential kidnapping scenarios.

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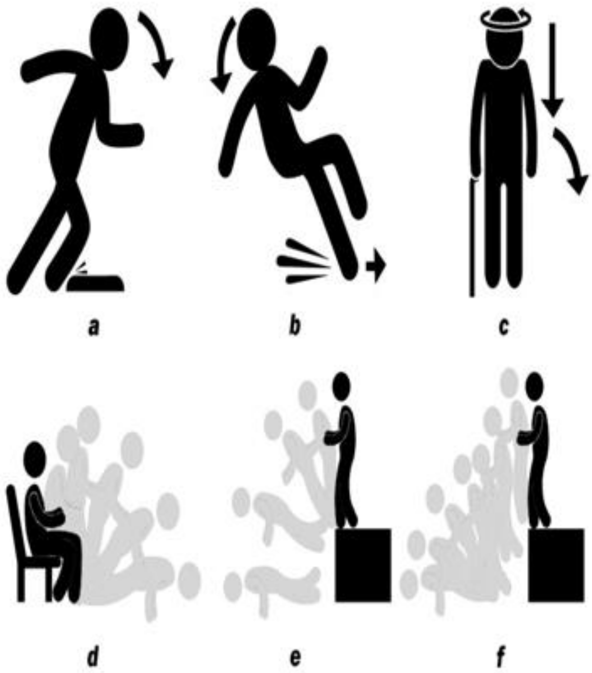

Fig 1: examples of different types of falls

Our wearable safety solution provides a proactive and adaptable way to improve personal safety and security by combining these features. This study contributes to the progress of wearable technology for better safety outcomes by examining the conception, application, and efficacy of our solution in reducing the risks related to falls and security threats

II. RELATED WORK

Smith et al. [1] developed a system using accelerometers on mattresses for unobtrusive activity tracking in nursing homes. They targeted detecting in/out of bed events, agitation events, and in-bed movements. Data collected via an Android app included movements like sitting, lying down, and standing up. The study achieved high accuracy, with 100% in a single location, 92% in multiple locations on the same bed, and 46-93% in different participants and beds. They demonstrated the feasibility of human activity tracking using unobtrusive sensors in a bed.

Sharma and Kaur [2] conducted a study comparing woman safety parameters in smart and non-smart cities. Smart cities integrate ICT and IoT technologies to balance social, ecological, and economic development. Despite technological advancements, crimes against women persist in smart cities. Technologies like LTE, 4G/5G networks, IoT, and wireless broadband are used in smart city development, with governments making efforts to develop safety devices and applications. However, there is fear and reluctance among women to use safety measures. Women's empowerment involves providing control and privileges to protect their rights. Persistent issues include violence, harassment, and unequal gender norms affecting women's freedom and education. The study emphasizes the need for more sophisticated safety measures and mobile applications.

Tan et al. [3] developed FenceBot, a safety monitoring system for the elderly outdoors, in response to challenges in elderly care and monitoring, particularly heightened by the COVID-19 pandemic. FenceBot employs a hybrid architecture with FenceBot Web and FenceMonitor, defining roles for User, Person in charge, and Health authority. It uses Bluetooth Low Energy for proximity detection and stopping point detection to analyze trajectories. Simulation results show a decrease in the number of infected people with increased app adoption, making FenceBot an effective solution for elderly safety monitoring.

Zhang et al. [4] developed a deep learning model to predict imbalance in elderly populations using sensor- based datasets. They address the need for smart monitoring systems with artificial intelligence due to the increasing elderly population. Using datasets from Sisfall and Cogentlab, they review existing studies on fall and imbalance detection, categorizing them into camera-based, sensor-based, and hybrid approaches. The study concludes that a twofold model considering both weak and strong signals is effective for predicting imbalance.

Sharma et al. [5] proposed an IoT-based Women Safety Bag to address the prevalent issue of women's safety in India. With a focus on empowering women during unsafe situations, the system is embedded in a handbag and includes components such as Arduino UNO, Wi-Fi module, GPS module, Buzzer, Camera module, GSM module, and Push buttons. When activated, the system sends location details via GPS and GSM (Push Button 1) and captures the attacker's image (Push Button 2), sending it to a predefined email. This system enhances the safety of women traveling alone by providing location information and capturing evidence of the attacker.

An IoT-based Hybrid Model for Child Security and Activities Monitoring, addressing the pressing issue of child safety. By integrating IoT components and sensors, such as alcohol and smoke gas sensors, a blood pressure sensor, and an IoT board, into everyday accessories like a backpack or clothing, the model aims to provide a comprehensive solution for monitoring children's activities and detecting potential threats like alcohol or smoke exposure. Previous research has highlighted the potential of IoT and sensor technologies in enhancing child safety, making the proposed model a promising approach in ensuring child security [6].

A study proposes an IoT-based Safety Gadget for Child Monitoring and Notification to address the increasing concern of child safety. It focuses on developing a wearable gadget connected to a mobile application, utilizing GSM, sensors, and IoT technology for real-time monitoring. The gadget tracks the child's location using GPS and sends sensor readings to the cloud and parents via IoT, with emergency messages sent using GSM if values exceed thresholds. The system provides real-time location tracking, geo-fencing, and emergency alerts, offering an effective solution for child protection [7].

A Remote Child Health Monitoring System and Personal Safety solution for monitoring children's health and safety during their commute to school. The system incorporates Arduino Nano, RFID, GPS, WiFi module (ESP-01), temperature sensor (LM35), and an ultrasonic

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sensor (HC-SR04). It aims to enhance child safety by tracking their movements, monitoring body temperature, and ensuring social distancing, particularly during the COVID-19 pandemic.Real-time notifications are sent to parents through the Blynk app, enabling them to make informed decisions about their child's safety [8].

A non-contact-based Child Activity Monitoring system using IoT, incorporating image processing for face detection. It aims to continuously monitor a child's temperature, humidity, and movement, with components including Arduino UNO, various sensors, GSM module, web camera, GPS module, alarm buzzer, and LCD. The system detects wetness in the cradle and alerts parents via SMS or video call, with IoT integration for data transmission over the internet.It offers a cost-efficient and reliable solution for continuous child monitoring [9]. A study also develops a Smart Foot Device for women's safety, activated by tapping one foot behind the other thrice. It includes components like a button, microcontroller, GPS, GSM, and buzzer. The device discreetly activates, sending the location to predefined contacts. It achieves 98% accuracy with decision tree ID3 classifiers, significantly enhancing safety. The device works by detecting the foot tapping motion, which triggers the microcontroller to activate the GPS to fetch the location and the GSM to send a message with the location to predefined contacts.[10].

A study is focused on developing a Child Monitoring System based on GPS and RFID for real-time tracking and safety. It addresses the lack of timely protection and supervision for children due to parents' work-related reasons. The system includes a GPS positioning module (MC20), RFID radio frequency module, temperature detection module (DS18B20), and gyroscope sensor (MPU6050). It provides real-time positioning through GPS, RFID for identity recognition, temperature detection for health monitoring, and gyroscope for movement status monitoring. The device uploads positioning data to the internet, updating real-time positioning every five seconds. It enhances child safety through real-time tracking and intelligent monitoring, offering the potential for widespread use in intelligent wearable products for child safety. [11]

Safety Watch based on the Internet of Things proposed a Safety Watch based on the Internet of Things. The device, functioning as a digital watch, features a safety mode ac- tivated by a panic button for automatic health and location updates. It includes pulse rate and temperature sensors for health monitoring, GPS for live tracking, SMS alerts, and an auto call answering feature. Shortfalls include dependency on the GSM network, potential uncertainties about the self- defense mechanism (nichrome coil), limited details on security measures, and scalability concerns [12].

Danger Detection for Women and Child Using Audio Classification and Deep Learning introduced a danger de- tection system for women and children using audio classi- fication and deep learning. The system focuses on screams as indicators of danger, utilizing STFT and Mel-Filterbank for signal processing. Six classification models, includ- ing MobileNetV2, InceptionV3, XceptionNet, DenseNet121, ResNet50, and ResNet101, were employed. Shortfalls include a small dataset leading to potential overfitting, variability in accuracy, limited addressing of background noise challenges, lack of in-depth discussion on model

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integration with real- world devices, and the need for improvement in the noise- canceling system without specifying techniques used [13].

Table (1): literature review

Sr. No.	Title/ Author Name	Method Used	Research Gaps
1.	Unobtrusive Activity Tracking in Nursing Homes Using Accelerometers on Mattresses Smith et al.	Android app, accelerometers embedded in the mattress to know in and out.	High accuracy in different participants and beds Improved accuracy in multiple locations on the same bed
2.	Woman Safety Parameters in Smart and Non- Smart Cities Sharma and Kaur	Comparative study	Fear and reluctance among women to use safety measures in smart cities
3.	Imbalance Prediction Among Elderly People Using Deep Learning (2022) Oussema Fakhfakh, Imen Megdiche ,Rejane Dalce,Thierry Val	Proposed a neural network architecture withfully connected layers for the experimental study.	A small dataset, imbalanced data distribution, lack of external validation ,ethical and privacy concerns in data gathering, and insufficient details on the algorithm and model
4.	FenceBot:An Elderly Tracking App for Mitigating Health Risks. (2021) Ana Cristina, Bicharra Garcia,Jobson Massollar	FenceBot, includes a web app (Fence Bot Web) and a mobile app (Fence Monitor). Proximity detection is achieved through Bluetooth Low Energy. Algorithm: Stopping Point Finding	Requirement for both individuals to have the app installed for proximity detection may Limit its applicability.
5.	Women Safety System with Nerve Stimulator using IoT Technology (2022) Chandra Sekhar Deepika.Y Rama Krishna M	Integrates GPS, anerve stimulator, and tools for swift alerts to authorities. The system aims to enhance women's safety, reduce response time, and enable real- time tracking using Arduino, GPS, GSM, and Zigbee technologies.	Delayed help system with limited defense, relying on a single alert system that leads to reduced communication and slower responses.

III. IMPLEMENTATION

In order to construct the wearable safety system, the research uses a multidisciplinary methodology that integrates firmware programming, hardware development, and mobile application development.

1. Mobile Application (BYOB)

The development of the BYOB (Bring Your Own Bracelet) mobile application (android version only) using android studio is a crucial aspect of the project, aimed at providing users with a user-friendly interface to interact with the wearable safety system. The BYOB app's user interface design prioritizes simplicity and intuitiveness, making it simple for users to enter personal information, emergency contact numbers, and customised voice commands. Users are guided through the setup process with the use of clear and simple layouts that make sure the necessary information is readily available and modifiable when needed.

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2. Bracelet Module

The ESP32 Microcontroller and MPU6050 Sensor are integrated into the Bracelet Module. For precise fall detection, the MPU6050 Sensor's ability to detect motion and orientation changes is essential. It sends information to the ESP32 Microcontroller while continuously tracking the wearer's motions. The ESP32 Microcontroller, which serves as the module's processing unit, examines the sensor data to determine when falls occur. It initiates alarms and establishes communication with the BYOB app to enable emergency contacts to receive notifications in real-time.

Fig 1: MPU6050, ESP32 microcontroller

Fig (2): preliminary working of the bracelet

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3. Chain Module

The ESP32-CAM Board, the MAX Microphone, and the NeoGPS Module are the three main parts of the Chain Module. A camera is built inside the ESP32-CAM Board, allowing for image capture capabilities. The BYOB app and the MAX Microphone exchange data and begin image capturing when the MAX Microphone receives speech commands that it has defined. The NeoGPS Module offers GPS functions concurrently, allowing for real-time location tracking. By enabling users and emergency contacts to track the whereabouts of the wearer in the event of an emergency or possible security threat, this integration improves the security features of the system.

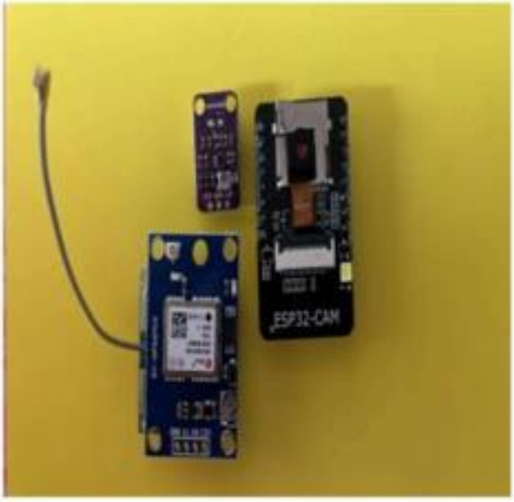

Fig 2: Camera module, Gps, microphone

4. Workflow

The below given diagram represents a wearable safety device that proposes a two-part system for fall detection and emergency response.

The core component is a sensor-laden bracelet equipped with accelerometers and gyroscopes. These sensors can detect falls by monitoring:

- Downward acceleration exceeding a specific threshold.
- Sudden cessation of movement after acceleration.
- Rapid changes in orientation.

Additionally, if the user exhibits no significant change in acceleration for 45 seconds after a potential fall, the device interprets it as a "serious fall" scenario. In such cases, the bracelet triggers an SMS alert to pre-programmed contacts, including details like the fall event.

This information is also sent to a central hub app named "BYOB Android App" for further action or record keeping.

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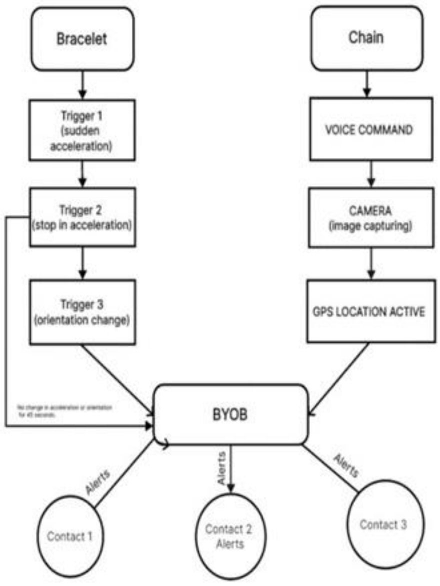

Fig (3): workflow diagram

The second component of the system is a voice- activated chain. Upon receiving a specific pre- programmed voice command, the chain activates the wearer's smartphone camera, captures a series of images, and retrieves the user's GPS location. This information is then transmitted to designated contacts, and also integrated into the BYOB Android App for further use.

IV. CONCLUSION

As our research concludes, we have made significant progress in developing a wearable safety system aimed at addressing fall detection and security concerns. By combining hardware elements like the ESP32-CAM board and MPU6050 sensor with the BYOB mobile application, we have developed a complete solution that improves security and safety for individuals. Our results emphasise how critical it is to use cutting-edge technologies to reduce the dangers related to falls and security concerns. Through its real-time monitoring, quick reaction capabilities, and easy communication with emergency contacts, our wearable safety system gives people the confidence and peace of mind they need to go about their daily lives.

V. FUTURE WORK

To improve system capabilities, future work in wearable safety systems will likely involve mixing machine learning and artificial intelligence (AI) algorithms with sensor technology advancements for more precise fall detection. To give real-time health information, studies may also concentrate on integrating biometric monitoring features. An additional area of investigation is the amalgamation of wearable technology with smart home appliances, which

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facilitates smooth communication and cooperation during emergency circumstances. These developments could ultimately boost users' safety and well-being across a range of demographics by further increasing the efficacy and usability of wearable safety systems.

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