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A Context-Aware IoT Framework for Enhancing Women's Personal Security through Smart Monitoring

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Abstract: *The paper presents a Wearable safety device for women using the Arduino ESP32 microcontroller, GSM Module and GPS, various sensors to know the distress situation, buzzer, shocker and many other components. The research purpose of this device is to safeguard women in the event they might face any danger. The device uses IoT to communicate with the secure channels and to send alerts to them. The device is programmed in such a way that as soon as the sensor get readings the distress situation is detected and processed. The GPS and GSM are used to ping the user's location directly to the relevant authorities and saved contacts. The additional switch in the device work for sending manual alerts in case of emergency. Blynk is an IoT platform that allows us to connect and save sensor data in the cloud and develop IoT applications. The advantage of this platform helps us in uploading the data on Blynk after every 30sec so that continuous health monitoring of the individual can also be done. Taking into account this, the previously mentioned framework is a wellspring of building up an item for people which helps in keeping up the security of the user by taking out the inclusion of users to start any procedural exercises against any circumstance which the user might feel at serious risk*

Keywords*:* IoT, Blynk, Women Safety, Arduino ESP32, GPS and GSM Module

I. INTRODUCTION

In today's world, women come across many situations that make them feel unsafe. Women from various walks of life face situations that make them feel threatened in different environments. Sixty-six per cent of women has reported sexual harassment in the year 2010 in New Delhi. It has also been proven that in urban environments, women are more prone to experience harassment especially in developing countries. In such situations, the aid of a safety device that will inform the victim's family members or the authorities may help women feel safer, confident and reduce the chances of harassment. Though there are a few Smartphones based solutions for the same, it might not be possible for the victim to reach for her phone in some situations without the knowledge of the perpetrator. Existing safety measures, such as mobile applications and wearable gadgets, provide some assistance but are often hindered by limitations. For instance, many solutions require internet connectivity, making them ineffective in areas with poor network coverage. Moreover, during emergencies, accessing a smartphone or app can be time-consuming and impractical. The lack of a compact, standalone, and reliable safety mechanism highlights a significant gap in the current safety solutions. This gap necessitates the development of an alternative device that ensures timely alerts, real-time location tracking, and user-friendly operation to protect women during emergencies and empower them in unsafe environments. These challenges underscore the need for a more dependable, standalone device that can operate effectively without relying on external factors like connectivity or user interaction.

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A robust and reliable safety mechanism is not just a tool but a step toward empowering women by enhancing their confidence and independence. By addressing these safety concerns through innovative technology, society can ensure a safer environment for women and foster their active participation in economic and social activities. This project aims to contribute to this vision by designing a user-friendly, internet-independent safety device for women. In this approach, the focuses on a security system that is designed merely to serve the purpose of providing security to women so that they never feel helpless while facing such social challenges. An advanced system can be built that can capture the video of the event as well as send the emergency messages of the victim through GSM to respective mobile numbers. The idea to develop a smart system for women is completely comfortable and also easy to use as compared to existing women security solutions such as infamous mobile apps, bulky belts and a separate garment that are just very abstract and obsolete.

II. LITERATURE SURVEY

Prof. Ankit Sanghavi, Purva Raut, Mansi Pokale, Sonal Tayade, Abhaysinh Deshmukh, "Women Safety System Using ARM Microcontroller and Arduino" -2024.

In the paper author presents a comprehensive women's safety system that integrates modern technologies to ensure effective emergency response. The system employs an ARM microcontroller, GPS module, Arduino Nano, pulse oximeter (MAX30100), temperature sensor (LM35), and a push button for emergency alerts. The device tracks the user's location, monitors vital signs like pulse and body temperature, and sends real- time alerts to a web app and ThingSpeak platform for remote monitoring. The system aims to provide continuous monitoring, instant alerts, and a reliable safety mechanism for women. The integration of cloud storage and real-time notifications enhances the device's usability and effectiveness.

T.P. Suma, G. Rekha, "Study on IoT Based Women Safety Devices with Screaming Detection and Video Capturing"-2021.

In the paper author proposes an IoT-based wearable safety device designed for women, utilizing Raspberry Pi equipped with a sound sensor, camera module, GPS, and GSM. The device activates when a scream is detected, using a Support Vector Machine (SVM) algorithm to filter out background noise and focus on the victim's scream. Upon confirming the scream, the camera captures a 30-second video, while the GPS tracks the victim's location. An alert, including the video and location, is then sent to the nearest police station via the GSM module. In a second scenario, when the user manually activates the device, the camera and GPS are triggered, and an emergency message is sent. The primary goal of this device is to provide a compact, portable, and reliable safety solution for women, distinguishing itself from other devices by its reduced size and improved functionality

Dhruvil Parikh, Pallavi Kapoor, Shital Karnani, "IoT-Based Wearable Safety Device for Women" -2021.

In the paper author presents an IoT-based wearable safety device designed to protect women in potentially dangerous situations. The device uses a NodeMCU microcontroller and IoT to communicate securely and send alerts when sensor readings exceed preset thresholds. The GPS and GSM modules are used to send the user's location to relevant authorities and emergency contacts. The device also includes two additional switches: one for manual alerts in emergencies and another to disengage the system in case of false alarms. Data from the sensors are uploaded to ThingSpeak, an IoT platform, every 30 seconds, enabling continuous health monitoring. This system provides an effective solution for women's safety, ensuring quick action in emergencies without requiring user initiation.

Rajini R (Assistant Professor), Chandrashekhar N, Shivakumar G, Shivashankar H, Shivakumar S (UG Students), "Women Safety Device"-2019.

In the paper author proposes that India, despite being a growing superpower, is still grappling with patriarchal challenges such as molestation, dowry, and crimes against women, including rape. Women's safety has become a critical issue, limiting their freedom due to fear of abuse and violence. The Women Safety Device aims to address this concern by detecting emergency situations. It uses a GSM module to send the woman's current location to emergency contacts.

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Additionally, the device is equipped with a shock giver circuit, which can incapacitate an attacker, providing the woman an opportunity to escape. This device offers a practical solution to enhance women's safety in emergency situations.

Muskan, Teena Khandelwal, Manisha Khandelwal, Purnendu Shekhar Pandey, "Women Safety Device Designed Using IoT and Machine Learning" -2018

In the paper author presents the increasing incidents of crimes against women necessitate effective safety solutions. Current safety devices and applications often require significant human interaction and rely on fixed thresholds for body temperature and heartbeat, which can lead to incorrect alarms. This paper presents a wearable woman safety device that uses IoT and machine learning to learn individual patterns of body temperature and pulse rate, improving alarm accuracy. The device collects sensor data during non-danger conditions to train a logistic regression algorithm. In emergencies, it detects abnormal readings and sends alerts, including location details, to multiple emergency contacts. A ZigBee mesh network ensures data transmission even in areas without internet access. The system's accuracy improves with more data, ensuring reliable emergency response.

Existing System

Several safety systems have been developed to improve women's security, such as smartphone-based applications and wearable gadgets. Smartphone apps, like SOS alert systems, allow users to send emergency messages with their location to pre-defined contacts or authorities. Wearable devices, such as smart bands or panic buttons, have also been introduced to assist users in critical situations by integrating technologies like GPS and GSM for location tracking and alerting.

Proposed System

The proposed system introduces a wearable safety device designed specifically to address the limitations of existing systems and enhance women's safety in critical situations. This device is a compact, standalone solution that utilizes GSM and GPS technologies, enabling real-time alerts and location tracking without relying on internet connectivity. It incorporates sensors such as force and IR sensors to proactively detect potential threats, making it an effective tool for immediate response and prevention.

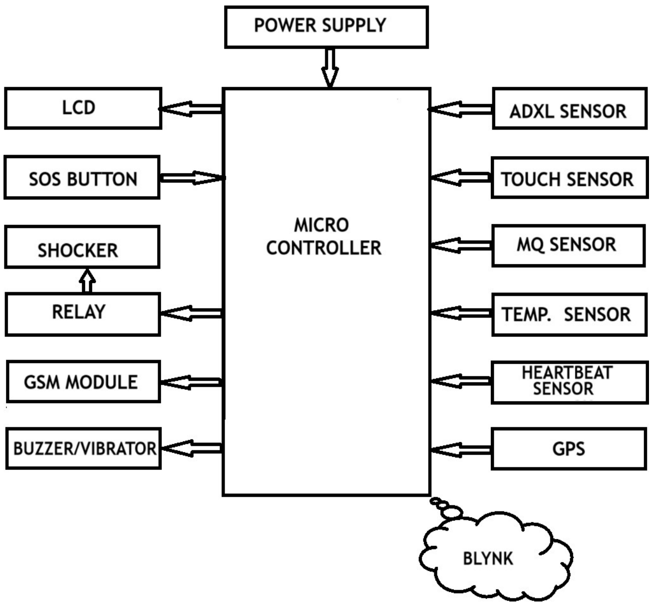

Fig 4.1: Block Diagram of the System.

- Automatic Alert Mechanism: In emergency scenarios, the device sends SMS alerts with the user's location to predefined contacts, such as family members or local authorities, using GSM communication.

- Proactive Evidence Collection: When the touch sensor is triggered, Python code is executed on a paired mobile phone to automatically capture images, providing critical evidence of the incident. These images can assist in post-incident investigations and legal proceedings.
- Proactive Threat Detection: Sensors detect proximity threats and trigger alerts through vibration and buzzer alarms, notifying the user and nearby individuals.

III. REQUIREMENT SPECIFICATION:

Software Requirements:

Embedded C: Embedded C is a programming language extension of standard C, designed specifically for embedded systems. It allows direct interaction with hardware components, such as microcontrollers, sensors, and actuators, while maintaining the structure and portability of the C language. Embedded C is widely used in real-time applications due to its efficiency, reliability, and ability to perform low-level hardware operations like accessing registers, managing I/O pins, and configuring peripherals.

In this paper, Embedded C is used to program the microcontroller, enabling functionalities such as reading data from sensors (e.g., heartbeat, alcohol detection), controlling output devices like the buzzer and relay, and triggering communication modules like GSM and GPS. It helps integrate various components to ensure smooth system operation. For instance, when an emergency is detected, Embedded C handles sensor input, processes the data, and executes corresponding actions, such as sending alerts or activating the shock generator. Its role is critical in creating a responsive, efficient, and reliable system for women's safety.

Python: Python is a high-level, versatile programming language widely used for developing applications, automating tasks, and integrating systems. Its simplicity, extensive libraries, and strong community support make it a popular choice for IoT, machine learning, and automation projects. Python's ability to handle hardware interaction through libraries like OpenCV, PySerial, and GPIO makes it ideal for embedded and IoT applications.

In this paper, Python is used to capture evidence through a camera when the push button is pressed. A Python script is implemented to interface with the laptop's camera (or an external camera module) to take photos or record videos at the press of a button. This feature helps document incidents in real-time, providing critical evidence in emergencies. Python's ease of use ensures seamless integration of hardware and software, enhancing the system's functionality and user-friendliness**.**

Blynk IoT Platform: Blynk is an advanced IoT platform designed to connect hardware devices with mobile or web applications seamlessly. It enables real-time data monitoring, device management, and remote control via interactive dashboards. Blynk supports various microcontrollers like Arduino, ESP32, and NodeMCU, and it uses Wi-Fi, GSM, or Bluetooth for communication. The platform also provides virtual pins for efficient data transmission and a user-friendly app for visualization and control.

In this paper, the Blynk Cloud Platform plays a crucial role in uploading and monitoring real-time data such as heartbeat, temperature, and location. Guardians or family members can access this data remotely using the Blynk app, ensuring constant monitoring of the user's safety. Additionally, the platform sends instant notifications and alerts during emergencies, facilitating timely action. Its scalability, customization, and ease of use make it ideal for IoT-based women safety systems.

Hardware Requirements:

Arduino ESP32: The Arduino ESP32 is a versatile microcontroller board based on the ESP32 chip by Espressif Systems. The Arduino ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth, ideal for IoT projects. It features dual-core processing, multiple GPIO pins, and supports protocols like SPI, I2C, and UART.

GSM Module: The GSM Module SIM800C is a compact and efficient module for mobile communication, supporting SMS, voice calls, and GPRS data over quad-band frequencies. It features low power consumption, making it ideal for IoT and battery- powered projects. With UART support, it integrates easily with microcontrollers like Arduino and ESP32, enabling applications such as emergency alerts, GPS tracking, and remote monitoring.

I2C Module: The I2C module is a two-wire communication interface using SDA (data) and SCL (clock) lines, enabling microcontrollers to connect with multiple peripherals like sensors and displays. It supports master-slave architecture, allowing efficient and synchronized data transfer. I2C is widely used in applications such as LCD displays, temperature sensors, and real-time clocks, offering simplicity and scalability for embedded systems.

LCD (Liquid Crystal Display): An LCD (Liquid Crystal Display) is a flat-panel display technology commonly used to show text, numbers, and graphics in embedded systems. It consists of pixels that can be controlled to form images and text when an electric current is applied. LCDs are energy- efficient, lightweight, and commonly used in devices like digital clocks, appliances, and microcontroller projects. A 16x2 LCD is frequently used in hobby electronics for its ability to display 16 characters per line on two lines, making it suitable for basic user interfaces.

Heart Beat Sensor: A Silicon Finger Clip-based Heartbeat Sensor uses infrared light to detect blood flow changes in the fingertip, allowing real-time monitoring of heart rate. The sensor is moulded in silicon for a secure fit, ensuring accurate readings as the finger is inserted. By measuring variations in blood volume with respect to time, the sensor calculates the heart rate. It is typically integrated with an OP-AMP for amplifying the pulse signal, making it suitable for use in health monitoring systems.

DHT Sensor: The DHT Sensor is a digital temperature and humidity sensor commonly used in embedded systems. It provides accurate readings of temperature (ranging from 0°C to 50°C) and humidity (ranging from 20% to 90% RH) with a simple digital output.

ADXL Sensor: The ADXL sensor is a 3-axis accelerometer used to measure acceleration and detect motion or tilt in a system. It can sense changes in velocity along the X, Y, and Z axes and provide real-time data about the device's orientation or movement. In this project, the ADXL sensor can be used to detect falls or sudden movements, which could trigger an emergency alert, making it an important component for women's safety. It is widely used in applications like wearable devices, fitness trackers, and motion-sensitive systems for monitoring physical activity or detecting accidents.

MQ3 Sensor: The MQ3 sensor is an alcohol gas sensor commonly used to detect ethanol vapours. It operates by measuring the concentration of alcohol in the air and providing a corresponding output signal. The sensor is widely used in breathalysers, alcohol detection systems, and other safety-related applications. It requires a heating element to reach its operating temperature and is typically interfaced with a microcontroller like Arduino for real-time detection and alert systems. The MQ3 sensor is known for its sensitivity, fast response, and reliability in detecting alcohol levels.

Touch Sensor: A touch sensor detects physical contact or pressure and converts it into an electrical signal. In this project, the sensor is used to trigger a relay, which activates a shock mechanism for self-defence. When the user touches the sensor, it sends a signal to the microcontroller, which in turn activates the relay. Touch sensors are commonly used in user interfaces, security systems, and embedded projects due to their ease of integration and responsiveness.

Relay: A relay is an electrically operated switch that uses a small current to control a larger current, allowing the activation of devices like motors, lights, or alarms. In this project, the relay is used to trigger the shock mechanism when the touch sensor is activated. When the sensor detects a touch, it sends a signal to the relay, which then closes the circuit to power the shocker.

Push Button: A push button is a simple input device used to trigger specific actions when pressed. In this project, when the push button is pressed, it activates the camera module to capture evidence from the phone or laptop, providing visual documentation in an emergency. Additionally, another push button triggers the heartbeat sensor to start calculating pulse rates, initiating health monitoring. This makes the push button an essential element for user interaction, enabling multiple functions in critical situations such as capturing evidence and monitoring health.

Buzzer: A buzzer is a simple sound-emitting device used to provide audible notifications in electronic systems. In this project, the buzzer is used to alert the user when alcohol is detected nearby through the MQ3 alcohol sensor. When the sensor detects alcohol vapors, the buzzer emits a beep to notify the user of potential alcohol consumption in the vicinity.

Shock Generator: The shock generator in this project is designed to provide a non-lethal electric shock for self-defence purposes when triggered by the touch sensor. For convenience and compactness, a mosquito killer battery is used as the power source, as it provides the necessary voltage for the shock mechanism while being portable. When the touch sensor is activated, the relay triggers the shock generator, delivering a mild shock to the attacker, enabling the user to escape from a dangerous situation.

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Working

The power supply initializes the microcontroller and connected modules. Sensors monitor the environment and physiological parameters in real time. If any predefined thresholds are crossed (e.g., alcohol detected or a fall occurs), the microcontroller activates the respective output devices, such as the buzzer, shocker, or GSM alert system. Alerts containing location and status information are sent to emergency contacts. Data from the sensors is continuously uploaded to the Blynk Cloud Platform, ensuring remote monitoring capabilities.

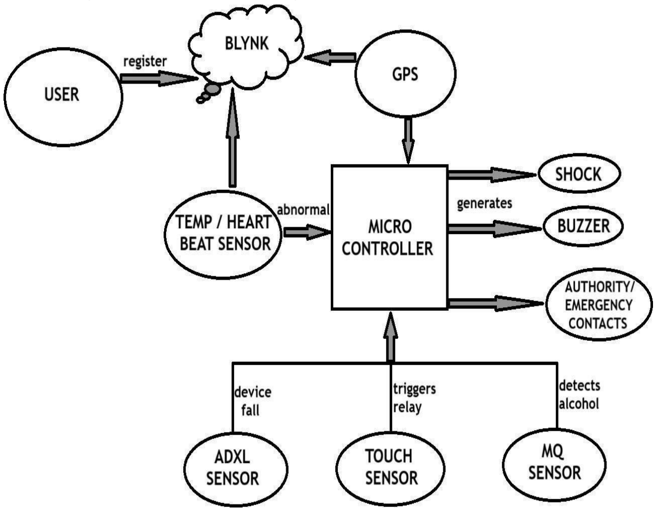

Fig: Data Flow Diagram

IV. RESULT AND ANALYSIS

The proposed smart Women Security device that is tested under different cases to obtain better results. Some real-time scenario was created where the user might feel insecure to see the efficiency of the system. These scenarios can be easily differentiated from any normal stress-causing activity using the disabling tactile switch at the same time emergency switch can be used to make the system forcefully work. Below are some pictures associated with the system.

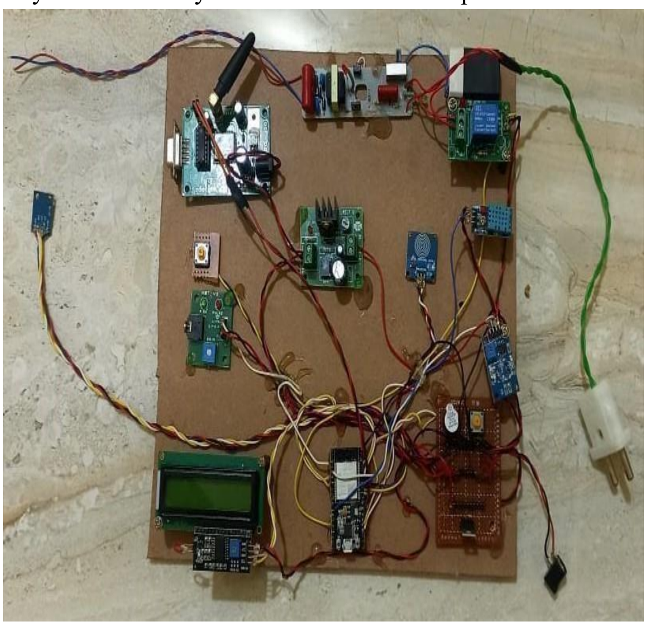

Fig: Smart Women Security System

Prototype Model

The Above Figure shows the prototype model of the project. The device contains components such as the microcontroller (ESP32), sensors (heartbeat, temperature, touch, alcohol, and ADXL sensors), output modules (LCD, buzzer, and shocker), and communication modules (GSM and GPS), all integrated into a compact design.

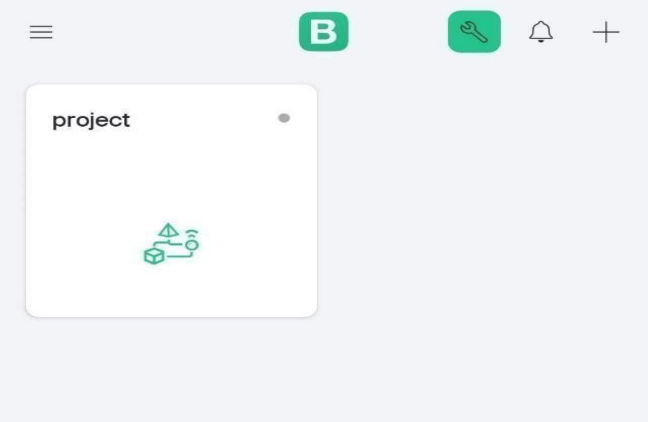

Fig: Blynk Application Home Page

The above figure highlights the gauge displays for heartbeat, temperature, and humidity, as measured by the respective sensors. The values are updated in real time and uploaded to the Blynk app under specific labels (Temperature, Humidity and Heart Beat), providing a user- friendly way to monitor critical data.

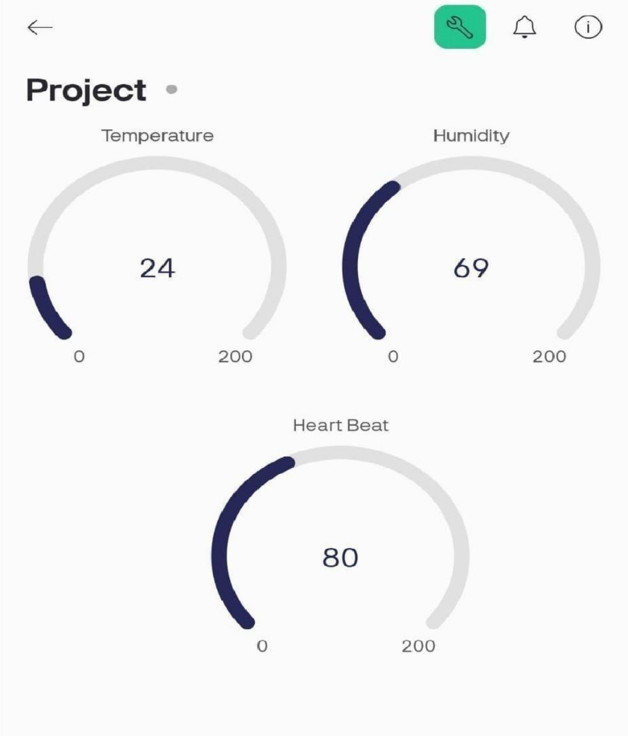

Fig: Sensor Reading in Blynk Application

The above Figure highlights the gauge displays for heartbeat, temperature, and humidity, as measured by the respective sensors. The values are updated in real time and uploaded to the Blynk app under specific labels (Temperature, Humidity and Heart Beat), providing a user- friendly way to monitor critical data.

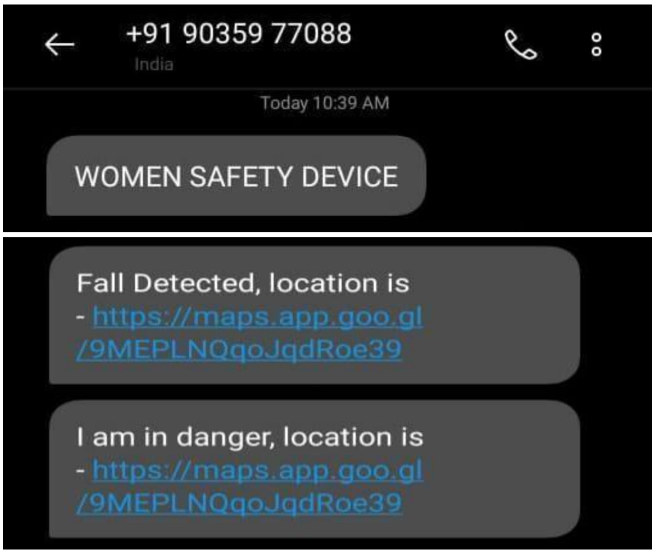

Fig: Alert Messages with Location

The above diagram shows the functionality of the location link included in the alert messages. By clicking or copying the link into a browser, the exact location of the distressed individual can be accessed via Google Maps, enabling rapid response.

Future Enhancement

Incorporate machine learning algorithms for more accurate detection of dangerous situations. Implement a voice-activated system for emergency alerts, allowing hands-free operation. Link the system to government safety services and law enforcement for faster response times. Develop alternative wearable designs, such as bracelets or pendants, for improved user convenience. Implement an offline mode to ensure alert functionality in areas with limited or no internet connectivity.

V. CONCLUSION

The project successfully demonstrates the integration of IoT-based technology to enhance women's safety through a compact, user-friendly wearable device. The system combines real- time monitoring, evidence collection, and alert mechanisms using sensors, GSM, GPS, and cloud platforms to ensure quick assistance during emergencies. The prototype effectively tracks critical parameters such as heart rate and temperature, detects dangerous scenarios like falls or alcohol presence, and sends location-based alerts to emergency contacts. The mobile application provides an intuitive interface for monitoring, adding further utility to the system. However, limitations such as dependency on network availability, power constraints, and environmental interferences were identified, which could affect the system's performance in certain situations. One key limitation was the integration of the GPS module; current GPS modules available in the market do not work well indoors or within buildings, as they require open surroundings for accurate location tracking. Despite these limitations, the project addresses a critical societal need by empowering women with a reliable safety mechanism, promoting both personal security and confidence.

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