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SAFETY BAND: AN INSTANT EMERGENCY RESPONSE GADGET

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ABSTRACT
The Safety Gadget is a compact, multifunctional wearable device designed to enhance personal security and provide immediate assistance in emergencies. It integrates manual emergency activation, fall detection, environmental hazard monitoring, and a discreet voice-activated alert system. Utilizing a Raspberry Pi microcontroller, along with a Pi camera, GPS module, motion sensors, gas and flame sensors, and wireless communication protocols, the system provides real-time video capture, location tracking, and emergency notifications. A buzzer and LED alert mechanism ensures that nearby individuals are also informed during an emergency. This paper presents the design, implementation, and effectiveness of the Safety Gadget, demonstrating its advantages over existing safety solutions.

Keywords:
Personal safety, Wearable emergency system, Automatic emergency alert, Hazard detection, Application integration.

I. Introduction

Personal safety remains a significant concern in today's world, where emergencies can arise unexpectedly in various situations, such as accidents, assaults, or medical conditions. Traditional safety measures, including mobile applications and panic buttons, often require manual intervention, which may not always be possible at critical times. The need for an automated, reliable, and easily accessible emergency response system has never been more pressing.

The Safety Band is a compact, wearable device designed to bridge this gap by integrating multiple emergency activation mechanisms into a single platform. Leveraging IoT technology, the device provides real-time alerts through a combination of manual triggers, automatic fall detection, environmental hazard monitoring, and voice commands. This holistic approach ensures that assistance is summoned swiftly, even when the user is incapacitated [2]. This paper details the design, development, and evaluation of the Safety Band, demonstrating its effectiveness in improving personal security and emergency response efficiency.

1.1. Related Work

Existing safety solutions, such as panic buttons, mobile applications, and standalone detection sensors, provide emergency alerts but often lack automation and integration. Wearable devices like smartwatches [1] offer limited safety features, such as fall detection and SOS alerts, but do not address environmental hazard detection. The Safety Band overcomes these limitations by combining multiple activation methods into a single wearable device, ensuring a more comprehensive and immediate emergency response.

II. Methodology

The design of the Safety Band incorporates a combination of hardware and software components, working together to detect emergencies and initiate appropriate responses. The system consists of an emergency activation module, a sensor network, and a communication framework.

A. Emergency Activation Mechanisms

The Safety Band provides multiple ways to trigger an emergency alert. Users can manually press a dedicated push button, ensuring immediate activation. Additionally, voice command recognition allows hands-free operation, which is crucial in situations where physical interaction with the device is not possible. Automatic fall detection is implemented using an MPU-6050 accelerometer and gyroscope module, which identifies abrupt changes in motion indicative of a fall. Furthermore, environmental hazard detection is integrated through flame and gas sensors, which monitor surroundings for fire and gas leaks, triggering alerts when dangerous conditions are detected.

B. Sensor and Hardware Integration

The device hardware comprises a Raspberry Pi 4 Model B as the central processing unit, interfacing with various sensors and modules. A Pi camera captures video footage upon emergency activation, while a GPS module retrieves real-time location data. The ESP8266 Wi-Fi module is used specifically to connect the pulse sensor to the device, ensuring accurate monitoring of the user's heart rate. Additional components, such as LED indicators, a buzzer, and a vibration motor, pro- vide real-time feedback to the user, confirming the activation of emergency alerts.

C. Communication and Alert System

Upon detecting an emergency, the Safety Band follows a structured response process. The Pi camera records a short video to capture situational context. Simultaneously, the GPS module retrieves the user's location, which, along with the recorded video, is transmitted to a preconfigured mobile application. The system ensures that emergency contacts receive real-time alerts, enhancing the likelihood of a swift response. The integration of multiple communication pathways strengthens the reliability of the Safety Band in critical situations.

2.1. Block Diagram

The block diagram represents the overall architecture of the Safety Band, illustrating the interaction between various hardware components and the flow of data. At the core of the system is the Raspberry Pi 4 Model B [6], which acts as the central processing unit, receiving real-time data from multiple sensors and executing emergency response functions. The device is powered by a 12V DC battery, which is regulated by an IC 7805 voltage regulator to provide a stable 5V supply for the Raspberry Pi and connected components.

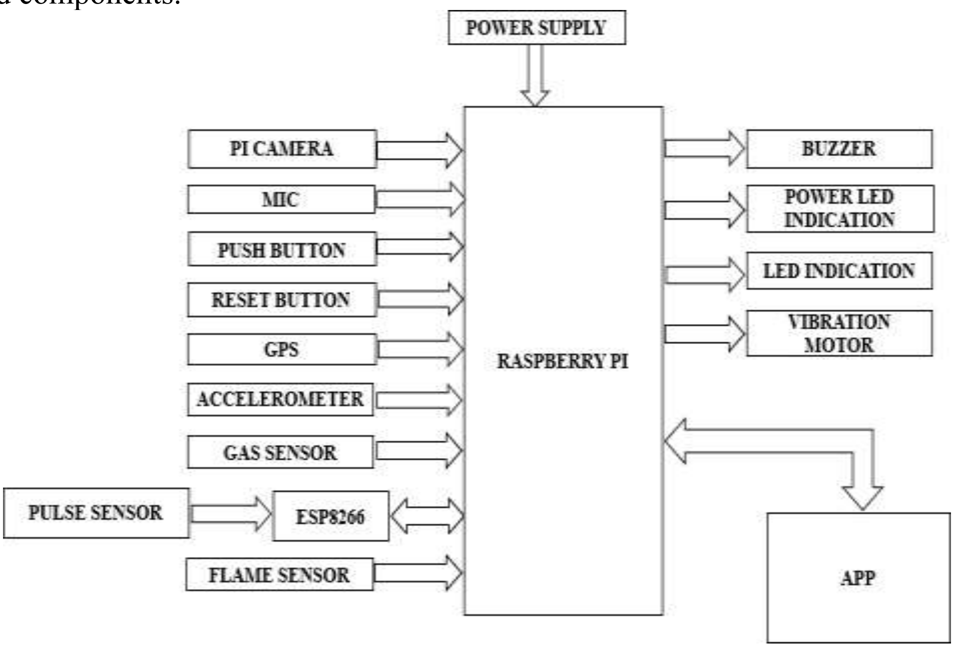

Fig.1. Block Diagram

The Safety Band incorporates multiple input sensors to detect emergencies. A push button allows manual activation of alerts, while the MPU-6050 accelerometer and gyroscope continuously monitor the user's motion to detect falls. The MQ-6 gas sensor and flame sensor ensure environmental safety by detecting hazardous gas leaks and fire, respectively. A pulse sensor tracks the user's heart rate,

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alerting emergency contacts in case of irregularities. Additionally, a microphone is integrated for voice-based emergency activation, enabling users to discreetly trigger an alert by speaking a predefined keyword.
Once an emergency is detected, the Raspberry Pi triggers the Pi Camera Module to capture a short video clip. Simultaneously, the GPS module retrieves the user's real- time location coordinates. This data, along with an alert message, is transmitted via wireless communication modules to a designated mobile application. To ensure immediate attention, the device also includes LED indicators and a buzzer, which provide visual and audible alerts. The block diagram effectively showcases how these components work together to deliver a real-time, automated, and multi-functional personal safety solution.

2.2. Flowchart

The flowchart outlines the logical sequence of operations in the Safety Band, detail- ing how the system processes different emergency triggers and responds accordingly. The process begins with the system in an idle state, continuously monitoring inputs from various sensors. If the push button is pressed, the device instantly initiates emergency protocols, including video recording, GPS location retrieval, and alert transmission.

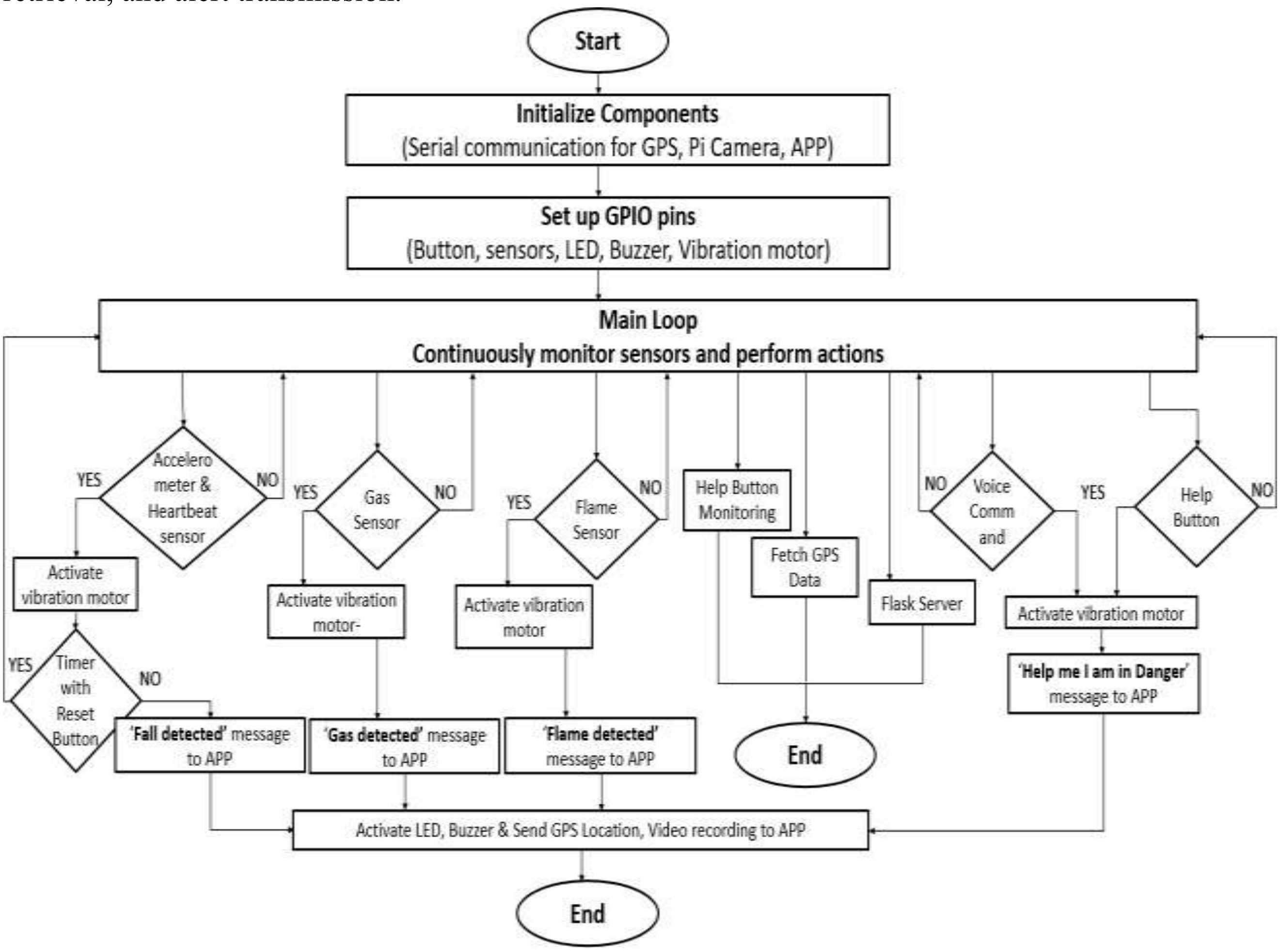

Fig.2. Flowchart

For automatic emergency detection, the MPU-6050 accelerometer continuously tracks motion data. If a sudden fall is detected, the system triggers an alert unless the user cancels it within a predefined time window. Similarly, the gas sensor and flame sensor monitor the surrounding environment. If hazardous gas levels exceed the threshold or a flame is detected, an immediate alert is sent. In parallel, the pulse sensor monitors heart rate variations, and if an abnormal pattern is identified, an emergency notification is generated.

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The voice activation feature provides an additional layer of safety, allowing users to trigger alerts without physical interaction. When the microphone detects the predefined emergency command, the system follows the same alert transmission protocol, capturing a video, retrieving the location, and sending notifications. The mobile application receives all alerts in real- time, displaying critical information such as live location, emergency video footage, and sensor status. The flowchart illustrates this structured approach, ensuring that the Safety Band responds efficiently to emergencies through multiple activation methods.

2.3. Design

The circuit diagram provides a detailed representation of the electrical connections and working of the Safety Band. The Raspberry Pi 4 Model B serves as the primary controller, managing sensor inputs, processing data, and executing emergency response mechanisms. The entire system is powered by a 12V DC battery, which is regulated to 5V DC using an IC 7805 voltage regulator, ensuring compatibility with the Raspberry Pi and other low-power components.

The MPU-6050 sensor is connected to the Raspberry Pi via I2C communication, enabling real-time motion tracking for fall detection. The MQ-6 gas sensor and flame sensor are interfaced through GPIO pins, continuously monitoring for hazardous conditions. The pulse sensor provides an analog output, which is processed through an analog-to-digital converter before being analyzed by the Raspberry Pi. The push button is wired to a digital input pin, allowing the user to manually trigger an emergency alert when pressed.

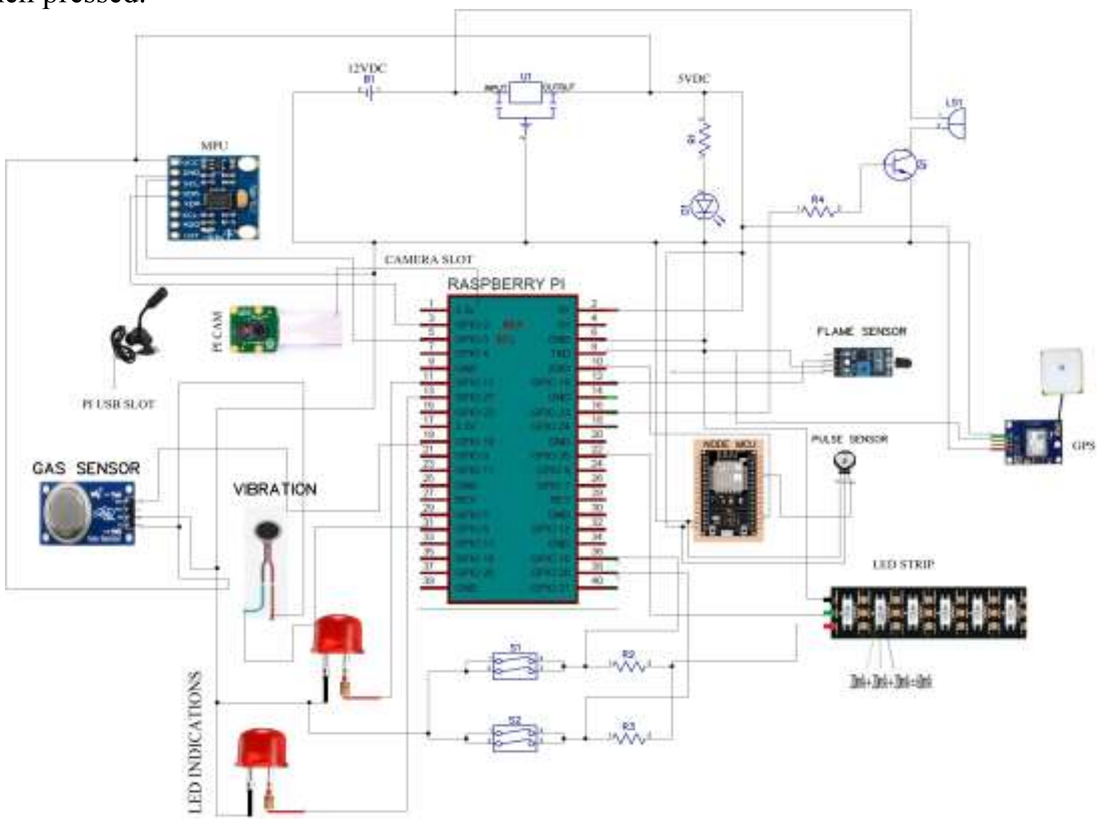

Fig.3. Circuit Diagram

For emergency communication, the circuit includes a Pi Camera Module, connected via the dedicated camera interface, which records video upon activation. The GPS module, inter- faced via UART communication, retrieves real-time location data. The system also features a microphone, which captures voice inputs for the emergency activation command. When an emergency is detected, the Raspberry Pi activates LED indicators and a buzzer to alert nearby individuals, while simultaneously sending alerts via wire- less communication modules to the mobile application. The circuit diagram effectively maps out these connections, providing a clear understanding of how hardware components interact within the system to ensure reliable and immediate emergency response.

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III. Result and Discussion

The development and testing of the Safety Band focused on validating its effectiveness under various emergency scenarios. The implementation involved assembling hardware components, programming sensor modules, and designing the communication framework for real-time alert transmission.

A. Manual Activation and Alert Transmission

The manual push-button activation was tested under different conditions, ensuring that alerts were consistently generated and transmitted to emergency contacts. The response time from button press to alert delivery averaged less than five seconds, confirming the system's efficiency.

B. Fall Detection Accuracy

The MPU-6050 sensor was calibrated to differentiate be- tween normal movement and actual falls [3]. Test scenarios included simulated falls from different heights and directions. The system successfully detected falls with an accuracy of 95 percentage, reducing false alarms by incorporating a cancellation option for the user.

C. Environmental Hazard Monitoring

The flame [5] and gas sensors were tested under controlled conditions to verify their responsiveness. The flame sensor successfully detected fire within a radius of 2 meters, while the MQ-6 gas sensor effectively identified hazardous gas levels, triggering timely alerts. This feature enhances the Safety Band's applicability in workplaces and households prone to fire and gas leaks.

D. Voice Command Reliability

Predefined emergency voice commands were tested across different environments, including noisy and quiet settings. The system demonstrated a high recognition rate, successfully ac- tivating alerts without manual intervention. This functionality ensures that users in distress can summon help even when unable to reach the device physically.

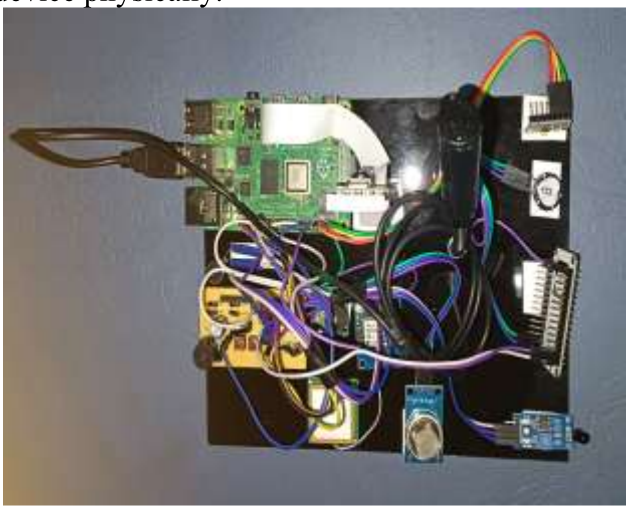

Fig.4. Hardware Setup

The circuit diagram illustrates the working of the Safety Gadget, a wearable emergency response system centered on a Raspberry Pi microcontroller, which serves as the primary processing unit coordinating all sensor inputs and outputs. The system is powered by a 12V DC source, stepped down to 5V DC through a voltage regulator (U1) to safely power the Raspberry Pi and connected components. The MPU6050 sensor (an accelerometer and gyroscope module) is interfaced via I2C (SCL and SDA pins), enabling fall detection by continuously monitoring the user's motion and orientation. A gas sensor and a flame sensor are connected to GPIO pins to detect hazardous gases and flames, respectively. When gas or flame is detected, the sensors send signals to the Raspberry Pi, which triggers alerts.

A Pi Camera Module is connected via the dedicated camera slot, allowing real-time video capture upon emergency triggers. The GPS module is linked through UART pins, providing real-time location tracking by sending latitude and longitude data to the Raspberry Pi. A heartbeat monitoring system is implemented using a pulse sensor connected to a Node MCU, which is interfaced with the Raspberry Pi. The pulse sensor continuously monitors heart rate, and a predefined threshold is set. If the heart rate exceeds this threshold, an alert is sent to the designated application, ensuring timely medical attention. Two push-button switches (S1 and S2) serve as manual emergency triggers or to cancel false fall alerts, while LED indicators provide visual feedback on system status or alert conditions. An LED strip is used for enhanced visual signaling during emergencies and is controlled through GPIO pins. Additionally, the circuit includes current-limiting resistors (R1, R2, R3) to protect LEDs and ensure proper cur- rent flow. The entire system is designed for real-time monitoring, where the Raspberry Pi processes sensor inputs, activates video and GPS modules, and sends alert messages to a designated application, ensuring comprehensive personal safety monitoring.

1. *Programming of Raspberry Pi*

Raspberry Pi is programmed to control sensors, process data, and execute automated tasks in embedded systems. It works by running an operating system, typically Raspberry Pi OS, which supports Python, C, and other programming languages. The Raspberry Pi interacts with components via GPIO pins, I2C, SPI, and UART interfaces. For instance, in project, it connects with a camera, heartbeat sensor, accelerometer, and GPS module to detect emergencies and send alerts. Programming enables real-time monitoring, automation, and communication with external devices like mobile apps, ensuring efficient data processing and response actions in safety and medical applications.

2. *Mobile Application Development*

A mobile application has been developed utilizing the Flutter framework, a popular choice for creating cross-platform mobile applications. The App [4] [7] connects with the wear- able device via a Flask server [8], enabling data exchange through serial communication. The app receives alerts from sensors (heartbeat, motion, gas, and flame) and notifies emergency contacts via GPS-based text alerts. Users can access live video streaming and review archived alerts. Voice commands and push-button triggers activate emergency protocols, including LED flashes and buzzer alarms.

Fig.5. Mobile Application

IV. Conclusion

The Safety Gadget represents a significant advancement in personal safety technology, offering a comprehensive and intelligent solution to address emergencies swiftly and effectively. By integrating features such as manual emergency alerts, automatic fall detection, pulse sensor monitoring, gas and flame hazard monitoring, and voice-command activation, the device ensures users are protected in a wide range of critical situations. The use of real-time video capture, GPS tracking, and instant alert messaging provides emergency responders and loved ones with accurate, actionable in formation, enhancing the chances of timely assistance and potentially saving lives. Its compact, wearable design, combined with seamless communication capabilities, makes it a practical and reliable tool for diverse user groups, including the elderly, lone workers, and individuals in high-risk environments. The Safety Gadget exemplifies the effective use of embedded systems, IoT, and sensor technologies in creating a proactive safety mechanism, and its potential for future enhancement promises even broader applications in personal, industrial, and public safety domains. Ultimately, this project highlights the transformative role of technology in promoting security, peace of mind, and well-being in an increasingly uncertain world.

A. Future Scope

The future scope of the Safety Gadget project is vast, with opportunities for enhancement, miniaturization, and integration into broader safety and healthcare ecosystems. The next step in development involves miniaturization through System-on-Chip (SoC) technology, reducing the current prototype's size to make it more compact and wear- able. This would allow for seamless integration into existing devices like smartwatches, enhancing user convenience. Additionally, a dual-system approach, with sensors placed in different locations such as one on the wrist and another on a neck- lace can improve monitoring accuracy by gathering complementary data.

Further advancements include incorporating biometric sensors to track vital signs such as heart rate, body temperature, and oxygen levels. This would enable early detection of medical emergencies like cardiac arrest or hypoxia, providing users with timely alerts and interventions. Sensor output-based prediction using ML and datasets can enhance the system's ability to recognize patterns, detect anomalies, and improve the accuracy of alerts. By integrating cloud storage and AI analytics, the system could enable real-time data logging, predictive analysis, and automated alert prioritization based on the severity of detected events. Machine learning algorithms can be employed to enhance fall detection and hazard identification over time, improving reliability. Additionally, the device could support multi-language voice recognition, making it more accessible to diverse users. To enhance safety and communication, the gadget can in- corporate two-way communication features, such as a built-in microphone and speaker, allowing direct contact with emergency services or caregivers during crises. Expanding into IoT ecosystems would enable the device to interact with smart home systems, such as triggering alarms, unlocking doors, or shutting off gas supplies during emergencies. Beyond personal use, the gadget has potential applications in industrial safety, child tracking, elderly care, military operations, and group safety monitoring, especially in remote or hazardous environments. With continuous advancements in wearable technology, battery efficiency, and sensor precision, the Safety Gadget can evolve into a discreet, intelligent, and proactive safety solution, seamlessly integrated into daily life.

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