

A Wearable Solution for Women's Safety

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Abstract - Women's safety is a critical concern in today's society. Despite technological advancements, existing safety devices are often bulky, unreliable, or ineffective in emergencies. This paper proposes a wearable solution in the form of smart footwear powered by Raspberry Pi Pico (a compact microcontroller used to control electronic devices). The device integrates GSM (Global System for Mobile communications for sending messages and making calls) and GPS (Global Positioning System for real-time location tracking) modules for real-time tracking and communication, ultrasonic sensors for obstacle detection, an SOS alert button, and a shock-based self-defense mechanism. Raspberry Pi Pico provides improved processing power, memory, and programming flexibility. Simulation and preliminary testing validate the effectiveness of the shock circuit and GSM-based alert system. This innovative integration of IoT (Internet of Things: connected devices exchanging data) and fashion aims to empower women by providing communication, navigation, and protection in a discreet wearable device.

Keywords — Women's Safety, Raspberry Pi Pico, Smart Footwear, GSM, GPS, IoT, Wearable Devices

1. INTRODUCTION

Women's safety remains a pressing global issue, with increasing incidents of harassment and assault. While several mobile applications and wearable devices have been introduced, many are limited by manual activation delays, lack of portability, or absence of a self-defense mechanism. Our proposed system integrates multiple safety features into a pair of wearable smart shoes, offering tracking, alert, and defense capabilities in a compact form. This paper presents the design, implementation, and evaluation of smart footwear using Raspberry Pi Pico as the core microcontroller.

As proposed in this work, smart shoes for women's safety comprise GPS and GSM modems & electric shock circuit. Inside this system, the GPS receiver detects the incident location using satellite data in the form of latitude and longitude. The GSM module will send a predefined SMS containing latitude and longitude data via the microcontroller.

The microcontroller processes the information for sophisticated use. The GSM modem sends a specific SMS, such as "I am in trouble," and also sends the device's current location to the predefined 5 mobile numbers. When a woman is in any kind of critical situation then the system can be activated by just pressing the panic button.

This project is a women's safety shoe that not only helps women take care of themselves but also helps them be fearless. This project makes use of GPS, GSM modules, and a shock circuit. Wearable electronic devices benefit from advanced techniques that allow for efficient energy harvesting, with the use of SMART SHOES being the most effective system for capturing energy. These shoes can monitor an individual's health by tracking their travel time, utilizing GPS technology to track their location.

II PROBLEM STATEMENT

Existing solutions for women's safety often fail to provide reliable and immediate assistance during emergencies. Mobile applications depend on user interaction and network availability, while physical tools like alarms or sprays may not be accessible when needed the most. The lack of a discreet, wearable, and multifunctional device can delay response time and reduce the chance of escape. Therefore, there is a clear

need for a compact system that can operate hands-free, deliver real-time alerts, and provide self-defense support. To address this gap, a smart safety shoe integrating Raspberry Pi Pico, GPS, GSM, a non-lethal shock module, and rechargeable power management (TP4056) is proposed to ensure faster response and improved protection in threatening situations.

III. OBJECTIVES

The primary objective of this project is to develop a wearable device that enhances women's safety by integrating multiple protective and communication features into a compact form. The system is designed to provide real-time GPS tracking, ensuring that the wearer's location can be accurately monitored whenever needed. With the press of a button, the device can automatically send SMS alerts and initiate emergency calls, enabling quick communication during critical situations. To offer immediate self-defense capability, a shock circuit is included as a protective measure. The entire setup is powered by a rechargeable battery system supported by a TP4056 charging module, ensuring reliable and continuous operation.

IV. BACKGROUND AND CONTEXT

Personal safety is a growing concern, especially for women in urban and semi-urban environments where harassment, assault, and unsafe travel conditions are increasingly reported. Several technological solutions have been developed, ranging from mobile applications to IoT-enabled wearables. However, many of these solutions have drawbacks, such as dependency on internet connectivity, user intervention, or visible devices that can be destroyed by an attacker [1]. Therefore, embedding safety features into footwear, which is both discreet and always carried, offers a promising direction for innovation [2].

GPS and GSM-Based Tracking

The Global Positioning System (GPS) is considered one of the most dependable solutions for obtaining live location information. When paired with GSM (Global System for Mobile Communication) modules, the

tracking system becomes more effective, as the GSM network can deliver the user's coordinates to emergency contacts through SMS without requiring internet access. Research on wearable safety devices has shown that combining GPS and GSM enables quick alert transmission and accurate position updates, making them suitable even in areas where mobile data coverage is weak. Despite these benefits, previous studies also point out a major challenge: these modules require significant power, which can drain the battery faster and reduce the device's operating time during emergencies.

IOT and Wearable Safety Devices

The growth of the Internet of Things (IoT) has led to the development of several wearable safety solutions such as smart bracelets, pendants, and watches that can send alerts during emergencies. These devices commonly include features like panic buttons, motion sensors, or health-monitoring components to detect abnormal situations. Although these wearables are innovative, their visible placement on the body makes them easy for an attacker to spot and disable. Research indicates that safety systems integrated into less noticeable items—such as footwear—offer a greater advantage, as they remain hidden and are difficult to remove or interfere with during an assault.

Smart Shoes for Safety Applications

Smart footwear technology has evolved from basic health-related functions, such as step counting and gait monitoring, to more advanced applications focused on personal safety. Some existing designs embed panic switches inside the shoe sole to send emergency alerts through GSM networks, while others experiment with pressure-based sensors to identify unusual force or sudden movement, such as a defensive kick. Although these models demonstrate useful concepts, many of them remain bulky, depend on external power sources like power banks, and lack thorough testing for long-term use. These limitations highlight the need for a compact, reliable, and rechargeable smart shoe specifically designed for continuous safety operations.

Self-Defense Mechanisms

Alongside communication-based alert systems, researchers have also investigated the use of direct self-defense features in wearable safety devices. Some models incorporate high-decibel alarms, while others use controlled electric shock modules to create temporary pain and discourage an attacker, giving the victim an opportunity to escape. However, studies emphasize that these protection features must undergo strict safety evaluation and follow legal regulations before being deployed in real-life situations. To ensure user safety, recent designs highlight the use of non-lethal current levels, which provide effective deterrence without causing physical harm.

PowerManagementandtheTP4056 Charger

A dependable power supply is crucial for the effective operation of any wearable safety device. Lithium-ion batteries are commonly used in portable electronics because they store more energy in a small size and can deliver sufficient current for longer periods. In many IoT applications, the TP4056 charging module is widely preferred because it supports both constant-current and constant-voltage charging while providing built-in safety features and easy charging through USB. Literature also notes that although the TP4056 module performs efficiently, careful heat management is required when placing it in compact spaces such as footwear, where airflow is limited. When paired with a DW01A protection IC, the system becomes even safer, as it prevents overcharging, deep discharge, and potential short-circuits, ensuring reliable operation in wearable designs.

Role of Microcontrollers: Raspberry Pi Pico

The Raspberry Pi Pico serves as an efficient and compact controller for wearable IoT-based safety devices. Built around the RP2040 microcontroller, it has gained attention for its small physical size, low cost, wide range of configurable GPIO pins, and support for common communication interfaces. Its dual-core architecture and low-power operation make it well-suited for handling tasks such as reading GPS data, managing GSM communication, and controlling additional peripherals simultaneously, including self-defense modules like shock circuits. Recent academic studies also highlight the increasing adoption of Raspberry Pi Pico in wearable applications,

particularly those focused on user safety and health monitoring, due to its practicality and reliability in real-time embedded systems.

V. PROPOSED METHODOLOGY

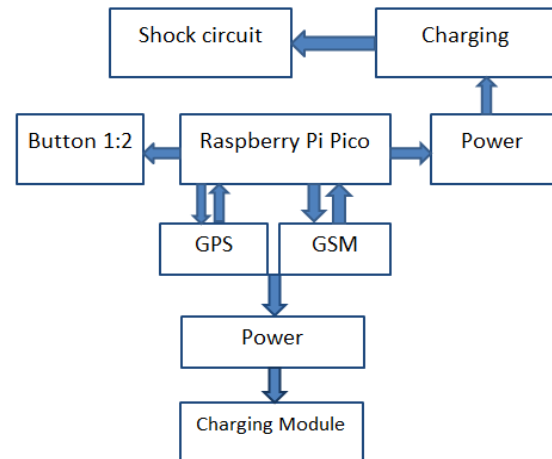


Figure 5.1: Connection method

Pico Pin	GPS Pin	Function
3.3V	VCC	GPS power
GND	GND	Ground
GP4 (UART1 TX)	RX	Pico → GPS
GP5 (UART1 RX)	TX	GPS → Pico

Table No.1. Raspberry Pi Pico to GPS Module (NEO-6M)

Pico pin	GSM Pin	Function
External 4V battery	VCC	Power supply to GSM
GND	GND	Common ground
GP0(UART TX)	RX	AT Commands→GSM
GP1(UART RX)	TX	GSM responses → Pico

Table No.2. Raspberry Pi Pico to GSM Module (SIM800L)

Pico Pin		
GP10	Button 1	SMS alert trigger
GP10	Button 1	
GP10	Button 1	Shock activation trigger
GND	All buttons	Common Ground

Table No.3. Raspberry Pi Pico to Push Buttons

Pico Pin	Shock Pin	Circuit	Function
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GP15	Trigger Input	Activates Shock Circuit
External Li-ion Battery	Power Input	Powers HV booster
GND	GND	Common reference

Table No.4. Raspberry Pi Pico to Push Buttons

Component	Pin	Connection
TP4056	BAT+	Battery positive
TP4056	BAT-	Battery positive
TP4056	OUT+	Power output to Pico & modules
TP4056	OUT-	Output ground
USB 5V	IN+	Charging input
USB GND	IN-	Charging ground
GSM Module	Direct Li-ion battery	Required for GSM high current
Shock Circuit	Separate Li-ion battery	Required for high-voltage output

Table No.5. Power & Charging(TP4056 + Batteries)

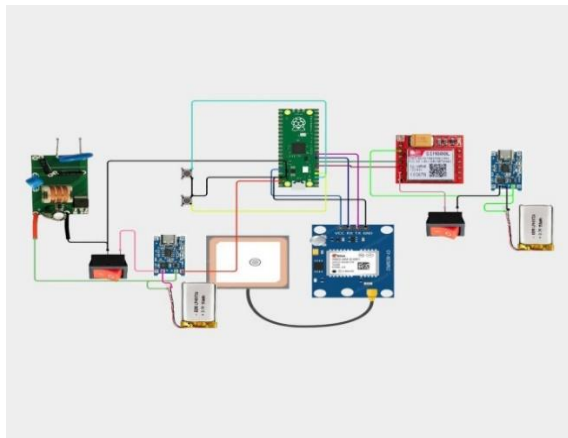


Figure 5.2: Circuit Diagram

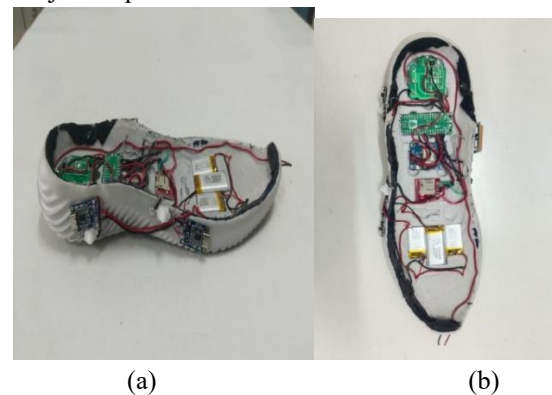
The proposed Smart Safety Footwear system combines GPS, GSM, Raspberry Pi Pico, tactile push buttons, a high-voltage shock module, and a multi-battery power management unit into a compact wearable platform designed for real-time protection and emergency communication. The overall architecture centers around the Raspberry Pi Pico, which acts as the primary controller and manages all functional modules. The Pico communicates with the NEO-6M GPS receiver through UART pins, collecting continuous location data from satellite signals. Using a similar UART interface, it controls a SIM800L/SIM900A GSM module to transmit alert

messages or initiate calls to emergency contacts whenever distress conditions are detected. These actions are triggered through three embedded push buttons that allow the user to discreetly select between sending an SMS with coordinates, placing a call, or activating the self-defense shock mechanism. The shock module is powered by a dedicated Li-ion battery and is enabled through Pico digital control, which switches a high-voltage boosting circuit to produce a controlled non-lethal discharge through metallic plates positioned in the shoe sole.

To support continuous operation in a compact form factor, the footwear integrates multiple Li-ion cells, where a TP4056 charging module ensures safe battery charging and stable output. The GSM unit and shock module are powered separately to handle high-current demands without disturbing the microcontroller or GPS communication. System operation begins as soon as the power switches are enabled, at which point the GPS begins location acquisition, the GSM registers to the cellular network, and the Pico remains in an active monitoring state waiting for user input. Once a button is pressed, the corresponding action is executed immediately without dependency on external devices such as mobile phones. This integrated methodology enables simultaneous tracking, emergency alerts, and physical self-defense within an unobtrusive wearable device suitable for practical use in critical safety scenarios.

VI. RESULTS AND TESTING

Project Implementation:-



(a)

(b)

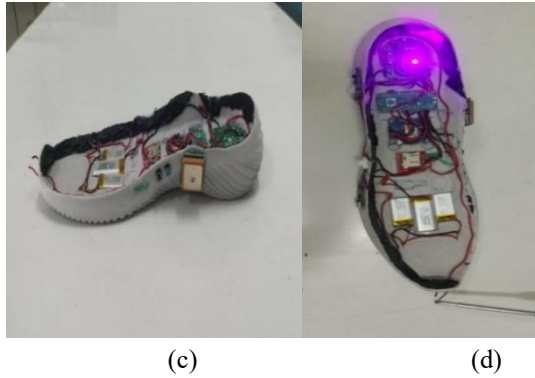


Figure 6.1 Shoe with hardware implemented (a)(b)(c)(d).

The project is implemented by embedding all electronic components inside a specially modified shoe sole, creating a compact and wearable smart-safety system. A Raspberry Pi Pico serves as the central controller, managing the GPS module for real-time location tracking and the GSM module for communication and emergency alerts. Rechargeable Li-ion batteries, along with dedicated charging modules and power switches, supply stable power to the entire circuit. Additional elements, such as the shock unit and control buttons, are integrated and connected to the Pico through carefully routed wiring. All modules are securely fixed within the shoe, ensuring reliable operation while maintaining portability and user comfort.

GPS Result:-

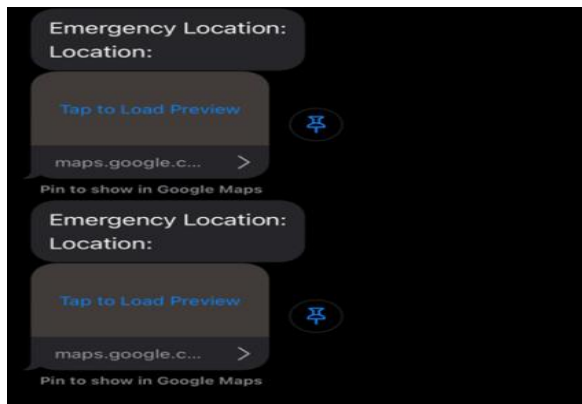


Figure 6.2 Location sent by user in emergency(demo)
The system successfully sends an emergency location message through the GSM module, providing the recipient with a Google Maps link for quick access. When the emergency button is activated, the device captures the current GPS coordinates and transmits

them as an SMS in real time. The received message displays a “Tap to Load Preview” link, allowing the user to open the exact location instantly in Google Maps. This confirms that the integrated GPS–GSM setup is functioning correctly and delivering accurate emergency alerts.

GSM Result :-



Figure 6.3 Emergency Call sent by user

The image shows the smart-shoe system actively performing its emergency call feature. When triggered, the GSM module inside the shoe automatically dials the preset contact number, as seen on the phone's screen. The internal electronics—GPS, GSM, battery units, and control circuitry—are securely integrated within the shoe sole, with the LED indicator confirming that the system is powered and functioning. This demonstrates the successful operation of the emergency-calling mechanism, providing immediate communication during critical situations.

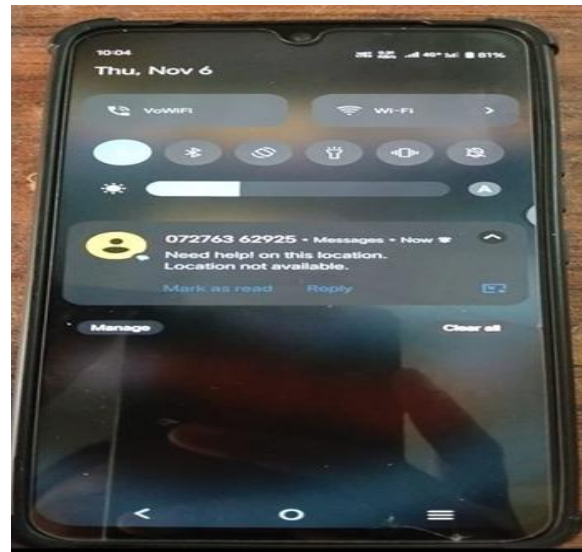


Figure 6.4 SMS sent by user for help.

The image shows a received emergency SMS generated by the smart-shoe system. When the alert is triggered, the GSM module sends a text message to the registered contact, indicating that the user needs help. In this instance, the message states that the location is not available, which can occur when the GPS signal is weak or temporarily obstructed. The notification displayed on the phone confirms that the communication feature of the device is functioning and capable of delivering emergency alerts to the recipient.

VII.FUTURE SCOPE

The smart wearable footwear system offers significant potential for enhancement and expansion in future iterations. Advanced communication features such as IoT-based cloud monitoring and mobile app integration can enable continuous real-time tracking and data storage. Incorporating biometric sensors—such as heartbeat, fall detection, and motion monitoring—could improve emergency detection accuracy and support health-related applications. The shock mechanism can be replaced or complemented with non-harmful self-defense options like sound alarms, pepper-spray activation, or LED distress signals. Future designs may also focus on miniaturization, improved ergonomics, waterproofing, and flexible circuits for enhanced comfort and durability. With further optimization, the system can be adapted for children, elderly individuals, outdoor adventurers, and high-risk professionals, expanding its usefulness across a wider range of safety scenarios.

VIII.APPLICATIONS

This smart footwear system can be used as a personal safety device for women, providing immediate assistance during emergencies through location tracking, call alerts, and a built-in defense mechanism. It can be deployed as a safety solution for children to help parents monitor their location in crowded or unfamiliar places. The device is also suitable for elderly individuals or patients with memory-related conditions, ensuring they can be quickly located if lost or in distress. Additionally, it can benefit individuals working in isolated, hazardous, or high-risk environments—such as security staff, delivery agents, night-shift workers, and field technicians—by offering

an accessible way to signal for help. Beyond personal safety, the integrated sensors and communication modules make it applicable to smart health monitoring, outdoor navigation, and emergency response systems.

IX.CONCLUSION

This work presents a wearable smart-footwear system built around the Raspberry Pi Pico, aimed at strengthening personal safety through integrated communication and self-defense features. By combining GSM-based alert messaging, GPS tracking, emergency push-button activation, and a compact shock-defense mechanism, the device demonstrates a practical and reliable approach to real-time safety support. The inclusion of a rechargeable power system using the TP4056 module further enhances portability and long-term usability. Experimental testing validates the system's ability to deliver accurate location data, initiate emergency alerts promptly, and operate its defense mechanism effectively. Beyond women's safety, the proposed design has the potential to be adapted for children, elderly individuals, and those working in high-risk environments, highlighting its flexibility and value as a scalable personal-protection solution.

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