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Smart Women's Safety Footwear with Moisture-Protected Taser and GPS-GSM Emergency Alert System

Parvathy M.[1], Subbulakshmi V.[2], Herlinzia C P.[3], Santhana Arumuga Sankari M.[4]

Assistant Professor, Department of Information Technology, Velammal Engineering College, Chennai, India.

Email: [1]parvathyganesh23@gmail.com, [2]vsubbulakshmi90@gmail.com, [3]ziaherlin@gmail.com, [4]sankarimk20@gmail.com

Abstract

The increasing situations of harassment and violence on women leads to inquiries regarding their safety. Traditional methods of personal defense, such as pepper spray and mobile applications are not rapid responses in an emergency situation. This paper proposes a method using footwear as a self-defense system includes a non-lethal taser (electric shock), built-in GPS (global positioning system) and GSM (global system for mobile communications) technology allows real-time tracking of the users exact location. The taser may be activated by the user of the footwear but it also has a moisture sensor that deactivate the taser if moisture is detected in the air. Once the taser is turned off, the GPS and GSM modules transmit an emergency location alert to the wearer's emergency contacts. The smart footwear may be used on a regular basis designed to respond the situations rapidly (within seconds) and provide a cost-efficient, portable personal protection method.

Keywords: Women's Safety, Smart Footwear, Self Defense System, Non-Lethal Electric Shock, Moisture Sensor, GPS Tracking, GSM Alerts, Wearable Technology, Emergency SMS Messages.

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1. Introduction

The increasing number of harassment, attacks and violence against women in both urban and rural areas shows the importance of women's safety. Many current solutions for increasing women's safety have been proposed with a focus on technology, but these solutions mainly focus on responsive rather than preventative measures. Existing technologies such as pepper sprays, personal alarms and mobile phone-based safety applications fail to provide users with efficient protection in high-risk situations. For example, many of these solutions will be inaccessible if consumers are nervous, require effort to activate or depend on wireless connectivity methods are not always safe. Furthermore, maintaining numerous security measures proves complicated for women and this causes irregular usage of such devices. To address this critical requirement for improved women's safety, there is an effective case for developing a comfortable, secure, portable, self-driven emergency response and self-defense system provides an immediate response to an emergency situation and a dependable way for the user to defend themselves without modifying the daily routine.

In response to these issues, a smart footwear for women's self-defense uses a manual switch to administer a non-lethal shock including real-time GPS and GSM for communication in situations of an emergency. Furthermore, a moisture sensor analyzes the conditions and immediately deactivate the shock function when moisture is detected, preventing random discharge when it rains or walking on wet floors. When the shock function is activated, the GPS module locates the user in seconds and the GSM module sends an emergency SMS to at least five pre-registered contacts allowing them to respond rapidly. All electronic components in the footwear made of rubber to protect both the electronics and the users ensure that the footwear is both safe and reusable. The proposed method is an economical, easy to use and scalable solution to standard self-defense techniques improve personal safety and the able to respond to the situations.

2. Related Work

In previous years, many new technology-based solutions have been developed to improve women's safety with the use of wearable and portable devices [1]. The various technologies being explored include smart safety products like wearable bands, necklaces and mobile apps use mapping and phone communication (GSM) technology to provide immediate data about the location of the user in an emergency situation [2]. All these systems either use a panic button to trigger a signal or use voice activation to send a signal for alerting the others consists of SMS or phone number alerts sent to pre-defined contacts. Some of the wearable products send an audible signal to alert nearby citizens or police from the user location [3]. These products provide an alert system and method to view the user's location, that they not include physical self-defence and placing users at risk in close range [4], [5]. In some cases, research has introduced self-defence by integrating electric shock technology such as handheld devices and the use of clothing items that provide an electric shock to an opponent to paralyze them for a short period of time [6], [7]. While these devices may have the capacity to prevent the one who is attacking. These devices are not always suitable for implementation under all circumstances (wet) and are not always easily accessible while in an emotional state. [8]. Additionally, the user may also be placed in a dangerous situation due to insufficient insulation of the handheld device used. Some researchers have proposed adding safety features to footwear to overcome the limitations of current systems as footwear are continually worn and it is misplaced [9]. The latest IoT-based safety technologies use sensors, microcontrollers and wireless communication technology creates an expandable and reliable system. Moisture sensors are used in safety-critical environments to prevent electrical hazards immediately disabling high-voltage systems when moisture is detected. Rapid location determination provided by GPS sensors and SMS alerts via GSM are common because they are inexpensive and have a mobile phone network [10].

This suggested technique combines a manually operated non-lethal electrical shock system activated within footwear, a moisture-triggered safety device and an automated emergency warning system based on GPS-GSM technology. This provides a safer, easier to use and cost-effective method of ensuring safety in daily life. The application of modern IoT technologies to the design of wearable electronics and embedded systems was used as the foundation for the development of smart safety solutions for women. Several research have demonstrated by integrating a variety of sensors such as accelerometers, pressure sensors, motion detectors and physiological sensors, a microcontroller-based architecture may be used to automatically recognize an individual's distress state. These automated systems are designed to identify signals of anxiety through irregular movement patterns with an unexpected effect, or a physiological change connected with fear.

3. Proposed Approach

The proposed work was designed to address the issues with existing devices for people to protect personally while away from home by including a non-lethal electrical shock mechanism that is manually activated with automatic emergency alerts sent via GPS and GSM technology. When compared to previous works, this system will provide physical defense against attacks, track the locations in real time and safeguard the user from being shocked if there is water in the surroundings. The system depends on modules that were integrated and utilized by an Arduino Nano microcontroller. Figure 1 shows the architecture of the proposed system.

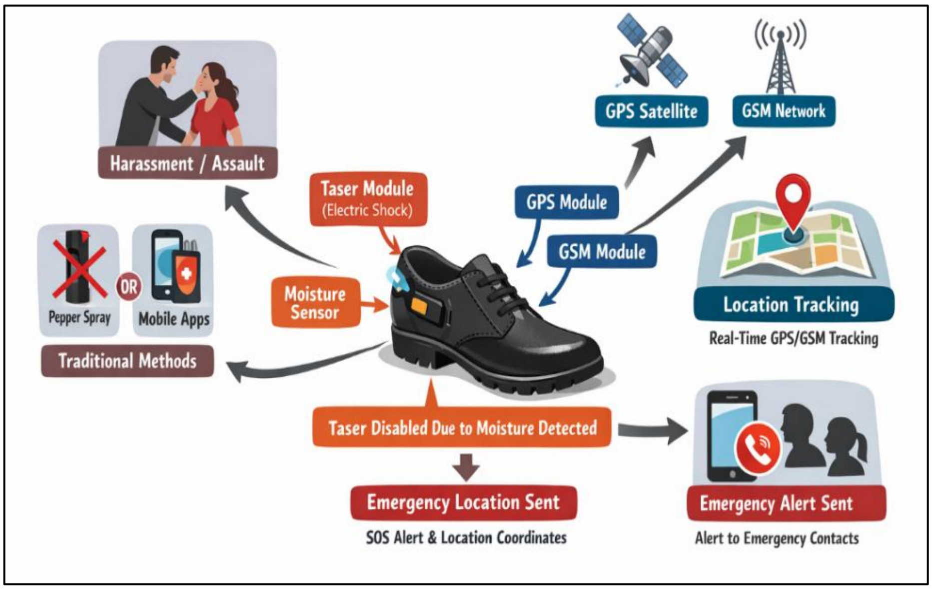

Figure 1. Architecture of Proposed Work

Figure 2 shows a flowchart of the techniques for integrating the manually controlled shock module with the automated emergency warning system using a GPS & GSM module and the moisture sensor. When the moisture sensor detects moisture, it rapidly disables the electrical shock mechanism to prevent random shocks. The GPS module immediately stores and analyzes the person's location, while the GSM module sends SMS notifications to preprogrammed emergency contacts.

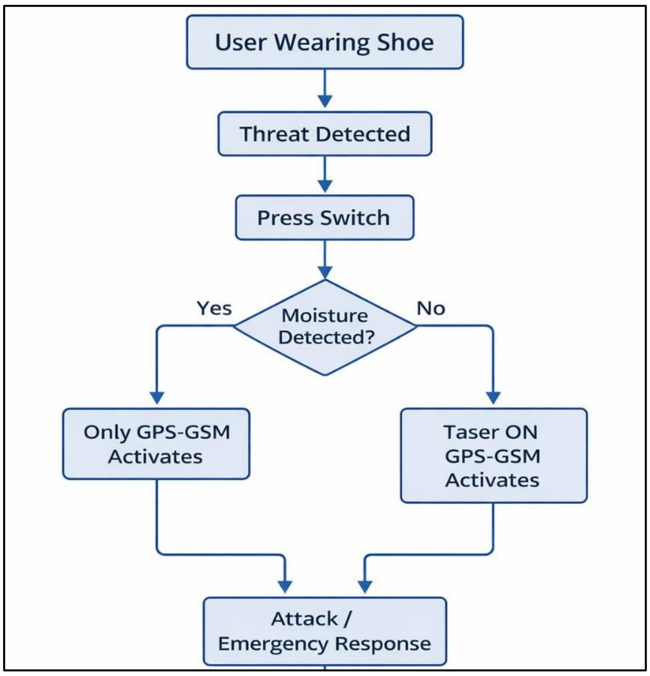

Figure 2. Flowchart of Proposed Work

3.1 Moisture Sensor

A moisture sensor [figure 3] is used to detect moisture. It sends a message to the Arduino Nano that disables the taser when detecting the moisture. The moisture sensor enables constant monitoring and is needed to provide a secure method for the system.

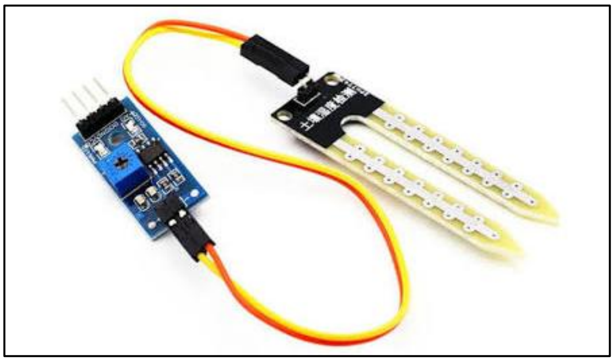

Figure 3. Moisture Sensor

3.2 Arduino Nano Microcontroller

The Arduino Nano [figure 4] is the brain of the system. It receives data from the moisture sensor, GPS and the electrical shock mechanism is activated using a user-controlled switch. The board triggers the electrical shock, monitors the moisture sensor readings and sends text alerts to the user's phone via the GSM module. The Arduino Nano is small and uses minor energy makes it easy to include in wearable footwear.

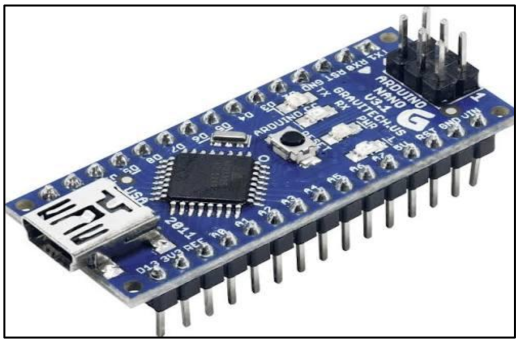

Figure 4. Arduino Nano microcontroller

3.3 Voltage Regulator

The voltage regulator [figure 5] converts the voltage from the battery so that it is equal to the operating voltage of the shock mechanism, GPS, GSM and moisture sensor. The voltage converter regulates the voltage and protects the entire system from voltage drops keeps the embedded electronics in the footwear safe and functioning properly.

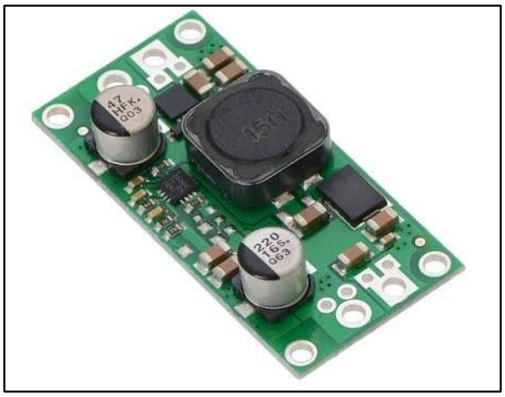

Figure 5. Voltage Regulator

3.4 Manually Activated Non-Lethal Shock Module

The purpose of this shock module [figure 6] provide a current-limited, non-lethal shock to possible attackers are using a manually actuated switch situated inside the footwear. Additionally, the shock module has been placed between two layers of insulating rubber, to prevent the possibility of accidental activation.

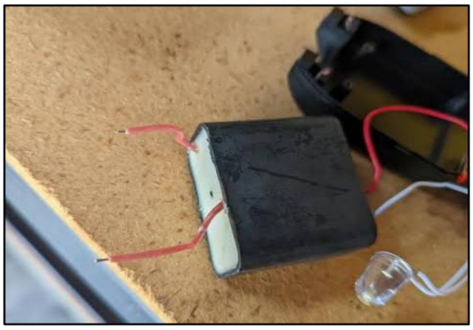

Figure 6. Manually Activated Shock Module

3.5 GPS and GSM Modules

The purpose of the GPS module [figure 7] is to acquire a location in seconds and the GSM module automatically sends an SMS message that contains the user's location to five assigned emergency contacts any time the shock module is triggered or the moisture sensor detects moisture. The GPS and GSM modules are connected and controlled through the Arduino Nano which facilitates rapid action.

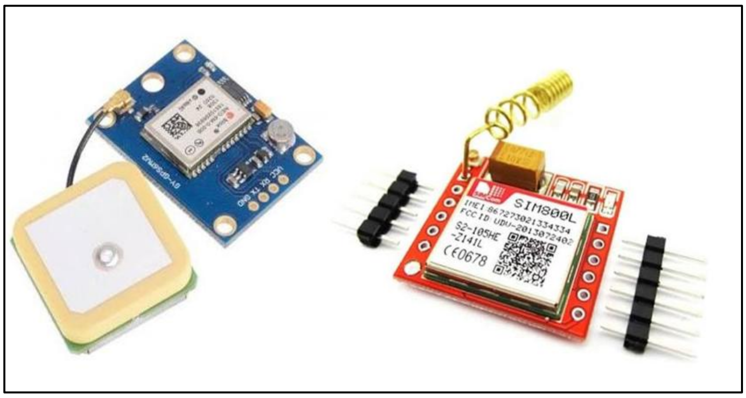

Figure 7. GPS and GSM modules

3.6 Footwear Design and Insulation

The shock module, moisture sensor, voltage converter and electronic components are all contained inside the footwear between two insulating rubber layers provide insulation and comfort to the user. This overall design allows for daily usage provides rapid access to the manual shock switch in the situation.

3.7 Charging Port

The device features a micro-USB port [figure 8] allows for efficient charging of the battery. This charging port connects to a voltage converter ensuring that the lithium-ion battery is charged in a safe and reliable manner providing uninterrupted use of the system during its lifetime.

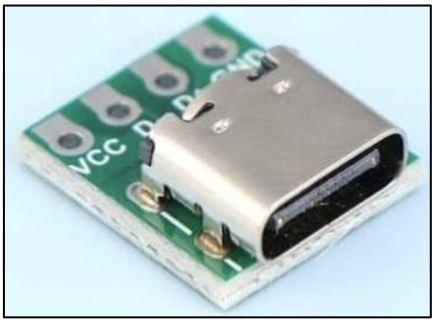

Figure 8. Micro-USB Charging Port

3.8 Electrodes

Electrodes [figure 9] are inlaid onto the inner sole of the footwear and are responsible for delivering the non-lethal electrical shock using conductive and non-harmful materials. The user's foot will be insulated from the electrode by a rubber layer prevents unintentional electrical shocks from occurring during normal use of the footwear.

Figure 9. Electrodes

3.9 Battery

This device uses a compact and rechargeable lithium-ion battery [figure 10] to power the entire system. A lithium-ion battery has been chosen due to its high energy density and its stability allowing reliable operation of the GPS, GSM, shock mechanism and sensors for long durations.

Figure 10. Batteries

3.10 Switch

The footwear incorporates a manual switch [figure 11] for activating the non-lethal shock module designed for easy access to the operator with an ergonomic design providing the best fit to the user's foot. The manual switch is integrated with the Arduino Nano to ensure that can operate it correctly and to utilize a secure feature.

Figure 11. Switch

The design is safe, reliable, effective and integrates physical self-defense, environmental sensing and emergency alerting capabilities into one wearable unit. This newly proposed design addresses the most significant issues of the previous devices and provides an effective, easily scalable solution.

4. Circuit Diagram

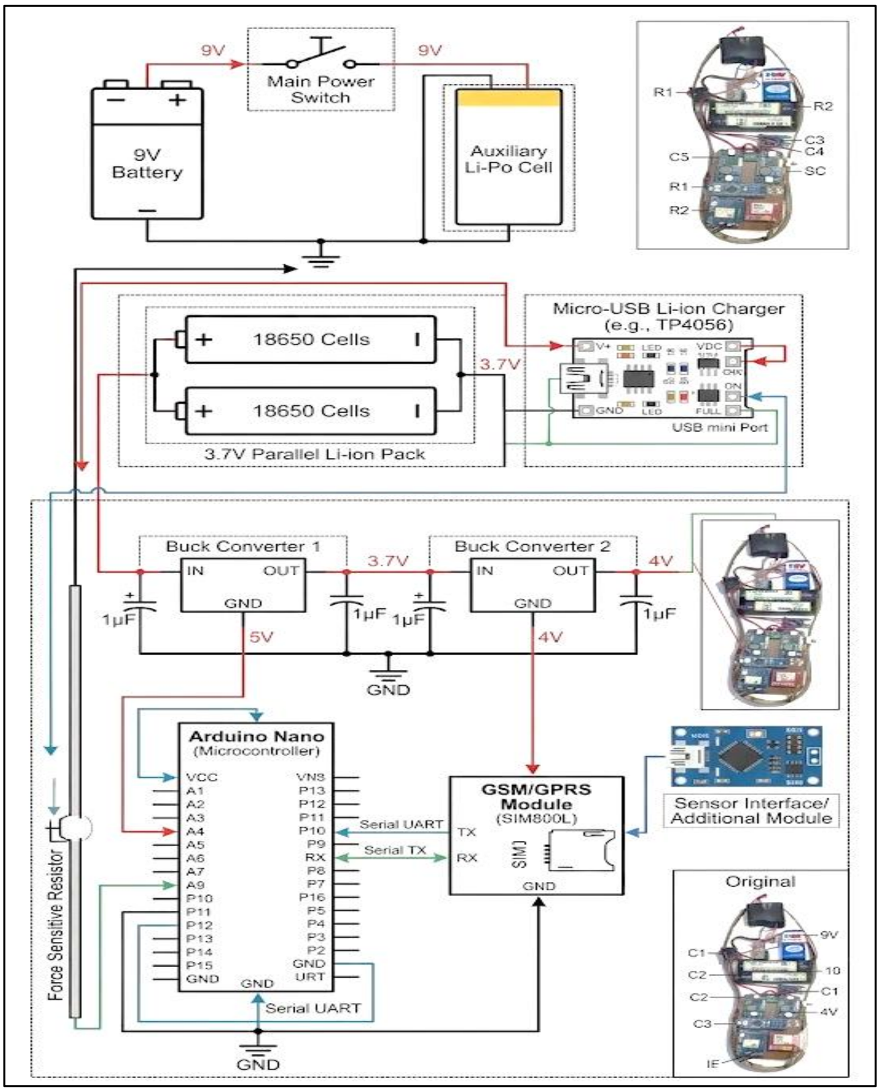

Figure 12. Circuit Diagram

Figure 12 represents the circuit diagram. This design is for a footstep-activated GSM tracking system designed to be placed on the person for safety purposes. Power is provided through a combination of a 9V battery and rechargeable lithium-ion cells (18650) charged via USB using a TP4056 charger module. The overall power switch operates all parts of this system. The voltage is reduced from both batteries using two buck converters; one converting to five volts to charge the Arduino Nano and another converting to around four volts to power the GSM/GPRS module (SIM800L) allow all components to work securely and dependably. A FSR is inserted into the shoe to sense pressure when the person walks. The Arduino Nano detects this change in resistance. When the Arduino detects foot steps or another trigger situation, it analyzes the signal and transmits it to the GSM module using serial UART connection (TX/RX pins). The GSM module sends an emergency alert message to the emergency services. If connected with a GPS module, the GSM module may also provide the user's location. This system has developed a smart, wearable safety device that automatically sends an emergency alarm when the user walks and provide better personal security applications.

5. Result

The implementation of the smart self-defence Footwear system achieved the successful testing of all modules include the manually activated non-lethal electrical shock, the Moisture Sensor, GPS, GSM Units. The Moisture Sensor consistently detected moisture (water) and disabled the Taser circuit for activation in wet conditions by permitting that both the GPS and GSM modules to work without interruption. The manually activated Shock Circuit function appropriately when tested in dry conditions and delivered a non-lethal and safe level of electricity while maintaining compliance with established Safety Standards. The GPS module was able to receive and transmit its coordinates within five seconds of activation and successfully forwarded the SMS Alerts to the Five predesignated Emergency Contacts.

The integration of all sensors and Microcontroller was continuously monitored and controlled through a Mobile App Interface provided real-time status updates for the Moisture Sensor, GPS Location and Shock Activation. All modules were able to function independently as a cohesive system enabling a fast response to an emergency while ensuring both safe operation and accessibility. The "Fail Safe" built into the system provides additional protection to ensure there is no possibility of activating the Shock Circuit if there is moisture present. This prevents the risk of the Shock triggering on someone when raining, sweating, or standing on a wet surface. The overall performance of the Smart Self-Defence Footwear System shows high level of reliability, ease to use and utility within daily life for users. Figure 13 represents the final design of the proposed system and figure 14 shows the SMS alert message that explains the real-time locatopm data.

Figure 13. Final Prototype of Smart Self-Defense Footwear System

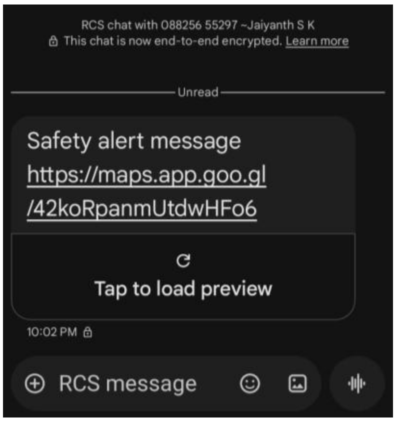

Figure 14. SMS Alert Output Showing Real-Time Location Information

6. Conclusion and Future Work

The current study recommends better self-defense footwear that maintains women safe in public. A footwear with an electric shock non-lethal mechanism operated by the user and moisture sensing as a safety feature. The footwear depends on the Global Positioning System (GPS) and the Global System for Mobile Communications (GSM) to track position and automatically demonstrate where the user requires help to preset contacts. This footwear features is an additional layer of protection. It may be used securely even if wet. This footwear's uses of GPS and GSM technology improves safety with rapid location confirmation and automatic alerting to emergency contacts. The proposed design of this footwear system will improve women's personal safety while maintain a simple, cost-effective technique. This footwear system was designed with the purpose of being small and invisible under daily routine activities allow women to be always prepared to protect themselves against attacks without stressing about the safety risks involved with wearing electric shock footwear in public.

Future works of this system include additional sensors such as accelerometers and gyroscopes will automatically activate alarms when attacks are detected without the need for user action. Mobile application alerts and cloud-based location monitoring will enhance communication, increase the effectiveness of police responses and provide real-time data using Low-power microcontrollers. This method may be further reduced and used to different wearables such as sandals, boots and other clothing items. This study demonstrates that there is potential for widespread use of this type of technology as an affordable, dependable and expandable system for maintaining personal safety. Additionally, future works may include artificial intelligence capability to detect attacks and generate automatic alerts.

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