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Smart Footwear for Women Safety with Hidden Alert System & Location Sharing

M Sharmila[1*], N. S. Patil [2], Pavan Krushna Kakde[3], Mahesh Rakesh Patil[4] , Gayatri Bale Shelke[5], Yashshree Sandip Shewale[6]

[1,2]Assistant Professor, Electrical Engineering, Sandip Institute of Technology & Research Centre, Nashik, Maharashtra, India

[3,4,5,6] Students, Electrical Engineering, Sandip Institute of Technology & Research Centre, Nashik, Maharashtra, India

Abstract

Safety is an important issue that needs to be addressed for women, which demands the use of intelligent and efficient devices to help in cases of emergency. These shoes contain an alert system that is hidden from view and have the ability to track location in real time. In case the wearer faces any danger, he/she will be able to send out signals discreetly without drawing unnecessary attention to him/herself. The Smart Safety Shoes incorporate different technologies such as a hidden button, motion sensor, GPS, GSM, and microcontroller. In case of danger, the wearer will be able to trigger the device through pressing the button or through a particular movement. After activation, an emergency signal with the current GPS location will be sent to a predefined contact list, which might include relatives or friends. Thus, help will be provided even if the person does not have his/her mobile phone. Lightweight, compact, energy-efficient, and low-cost shoes have been considered while designing these safety shoes. All parts of the technology have been integrated safely into the shoes in such a manner that there is both durability and concealment ensured. The use of Internet of Things (IoT) technology has made it possible for this system to offer an effective means of ensuring personal security. In conclusion, this research has highlighted the power of wearable technology in making women feel safe. Some of the improvements that can be done in future include adding an application that interfaces directly with the emergency services and can send location information via the cloud.

Keywords: Women's Safety, Wearable Devices, Internet of Things (IoT), GPS Technology, GSM Technology, Emergency Alerting System

Introduction

Overview

Today, the safety of women has become one of the key issues due to the increasing cases of crimes and emergencies. Most of the safety equipment available to us now—such as panic buttons or alarm clocks—needs active involvement of the users themselves. However, in moments of danger, an individual may find it hard to respond immediately, especially when they are panicked.

It is possible to create a more advanced version of safety equipment by utilizing the technologies like embedded systems, global positioning system (GPS), general packet radio service (GSM) and the Internet of Things (IoT). Advanced technological gadgets are able to sense danger and automatically send messages to the concerned people.

The goal of our project is to design a portable safety gadget for women. The idea is to use sensors, GPS and GSM technology to identify any emergencies. Once identified, the device sends the location of the person as well as an emergency message to selected recipients, such as family members or police.

Motivation

The main reason for engaging in this project is the increasing requirement for advanced and intelligent safety methods for women. Women face many dangerous incidents throughout the day, and the current solutions are not very efficient since they require the involvement of the users.

The goal of this project is to create an automated system that enables quick assistance to be provided during emergencies. Some of the goals of this project include the following:

* Shortening the amount of time required to receive help during emergencies.
* Designing a system that is small in size, portable, and easy to use.
* Adding features like automatic messages, sound alarms, and flashing lights to the system.
* Using technology to build a more alert society.

1.3 Problem Definition

n today's time, many safety devices are present, yet all of them have certain flaws which can be pointed out:

* In most cases, the functioning of these devices depends on pressing the button by the user.
* They usually give just one notification and do not update the user's location constantly.
* They lack sophisticated sensors to sense any dangerous situation.
* Some devices are cumbersome to wear or use.
* There is no feature which can help in gathering evidence through audio or video.

These weaknesses necessitate the creation of a better system. Therefore, it becomes the aim of the present project to develop an efficient and automatic smart system.

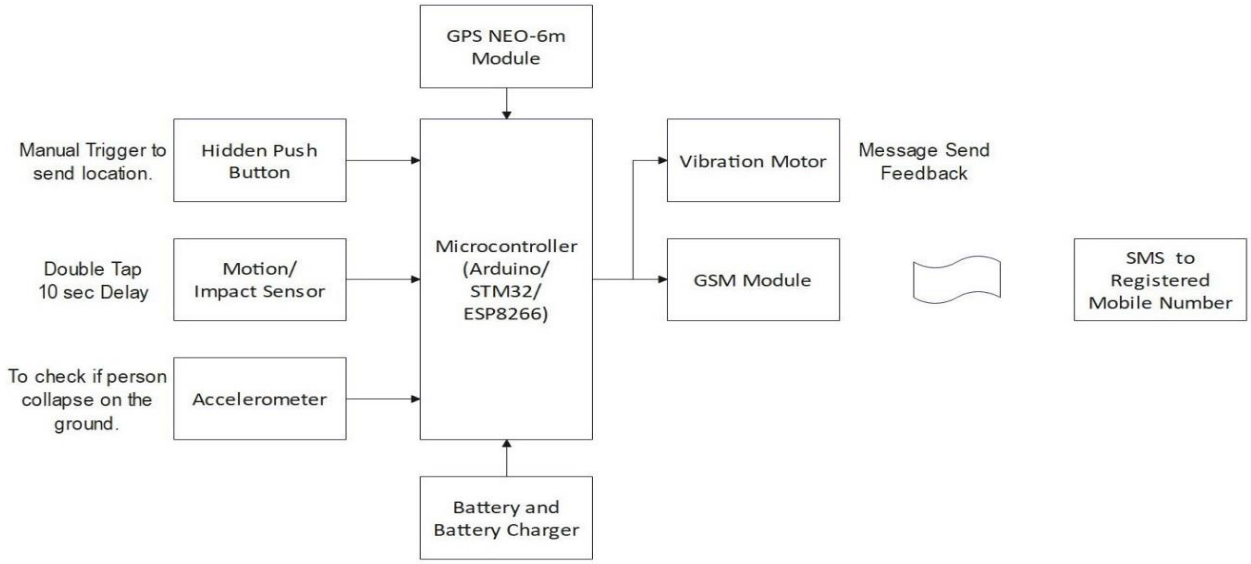
Literature Review

In most cases, the safety systems for women depend on GSM and GPS technologies, and allow sending distress calls. In times of peril, the systems send out the coordinates of the endangered person to those people preselected by her. The problem here is that the majority of such safety systems are based on communication technologies only, without any advanced "smart" features [1]. Another problem with existing security solutions is that they cannot be activated automatically, but only manually (for instance, pushing the button). In case of an emergency, the woman will not have time to press the button because of panic, injury, or simply because she will need a moment to think about it [2]. There are also some modern safety systems which consist of two components: a portable gadget and a special application on the mobile phone. Such safety systems have advanced features like real-time tracking and specifying safe areas, however, they cannot work without a smartphone or an Internet connection [3]. In some cases, certain devices try to make the process fast by enabling contact between the user and those around him/her or any volunteers within the vicinity. When an alert is activated, people within the vicinity will be notified, thereby making it easier to assist. Nonetheless, this type of technology may not necessarily work because its success depends on having someone near enough willing to offer assistance [4]. It is also worth mentioning that some devices contain defensive mechanisms that may include the use of alarm, electric shocks, strobe lights, and others. The purpose of these is to scare off the intruder. Notwithstanding, how helpful these features might be greatly depends on the particular situation at hand [5]. In addition, some devices activate only one-time alerts without giving further location updates. This means that responders will not have a clue as to whether the person in danger is still in that place. Therefore, it is important that these alerts continue giving further information until the problem is sorted out [6]. One more limitation of such devices is that few of them come with sensors or automatic mechanisms that can track abnormal heart beats and other warning signals [7].

Control Strategy and Circuit Operation

Circuit Diagram:

Fig 3.1: Block Diagram



Microcontroller (Arduino Nano):

The Arduino Nano controls the whole operation in this project. It handles tasks such as gathering data from various sensors, communicating with the GPS and GSM modules, managing signals output by devices, and making decisions on whether to detect falls and/or send text messages.

GPS Module (NEO-6M):

The module determines the precise location of the person. It passes data to the microcontroller through serial communication and provides useful information such as the latitude, longitude, and current time to assist in sending the emergency alerts.

GSM Module (SIM800L):

The GSM module sends out messages in case of an emergency. It communicates with the Arduino using AT commands and facilitates the delivery of texts.

Hidden Push Button:

The push button serves as a means of contacting emergency services. This particular button is concealed and ensures that the user turns on the system covertly. Techniques are applied to avoid accidental pressing.

Motion/Impact Sensor:

This sensor detects rapid motions and double taps from the person. When the motion sensor gets a double tap at a specified rate, it triggers the sending of emergency alerts. There may be a delay introduced to avoid any accidental triggering.

Accelerometer (MPU6050):

MPU6050 measures body motions and orientations. It recognizes falls and lack of movements for some period to detect if there are problems. When it detects a fall and the absence of movements, an alert will be sent by default.

Vibration Motor:

The motor vibrates to notify the person about various situations. Vibration patterns are employed to inform a user of various conditions including on/off status, successful or failed messaging, and many more.

Battery and Charging Unit:

The system relies on a rechargeable battery connected to the charging circuit. The design ensures that sufficient power is delivered, especially when high demands are made by GSM, to ensure that the user is always protected.

System Description

New technology has been invented that helps users feel safe. The technology entails an intelligent alert system incorporated into the shoe. It provides an instant response to an emergency situation as well as tracking of the user's location. All the components are fitted inside the shoe. Therefore, the system works unobtrusively, and the user feels comfortable wearing it. There are the following components: a microcontroller-driven control unit, GPS module, GSM module, trigger hidden from prying eyes, vibrating feedback, and a battery. The system works independently since it does not require any external support or other people's aid. All the electronic components are incorporated into a compact shoe. Power subsystem. This subsystem consists of a lithium battery with a TP4056 charging module. The current and voltage are precisely managed to avoid overloads. The battery can be charged using a USB connector. It has built-in overcharging and discharging prevention, as well as LED indicators of charging status. All the components of the test system work together. The trigger mechanism is monitored. In case the system is in the passive mode, there is almost no consumption of energy. Upon activating the trigger, the system quickly processes information about the user's location and sends an emergency message to pre-programmed contacts.

1. Location Tracking and Alert Transmission

Location tracking system based on a GPS module; transmission of alert message through a GSM module.

Operation principle: The module receives coordinates of latitude and longitude from satellites. The microcontroller processes the received information and makes an appropriate transformation. The GSM module sends an SMS to family members or friends.

Content of alert message:

* An emergency message (a text message)

* Coordinates of latitude and longitude of user location

* Map (optional).

2. The user is quickly found, and emergency services are contacted immediately.

Triggers play the main role in this system as they launch it upon receiving the command to activate. The trigger mechanism can be easily concealed but easily accessible during emergencies.

Methods of Trigger Activation:

* Trigger types

* Pressure switch: Activation when pressing a certain part of the shoe.

* Tap sensor: Detection of two or more tap gestures

* Hidden manual button: A trigger that can be manually activated.

Upon activation of one of the triggers, the system starts working instantly, and nobody knows anything about it.

Power Management System:

It has a clever algorithm used to regulate the battery to allow it to perform uninterrupted.

Battery Specifications

Type: Lithium-ion (one cell)

Nominal Voltage: 3.7 V

Charging Voltage: 4.2 V

Charging Module: TP4056

Charging Capabilities:

• Charges up to 1000 mA of current

• Uses constant current & constant voltage technique

• Recharges itself after using it

• Provides trickle charging when battery level falls below 2.9V

• Gradual charging begins to prevent surges

• Displays status using output pins

The design of the power system ensures that it operates within specified ranges of voltage and temperature making it safe and reliable hence increasing its longevity.

3.4 System Safety and Reliability:

Safety and reliability features in the system ensure safe and continuous operation include the following:

• Protection from overcharge by regulating the voltage

• Maintains safety temperatures by regulated heat ranges

• Can tolerate short-circuits to a particular extent

• Functions reliably in diverse environmental conditions

3.5 Working Process:

The process of work involves a sequence of events that includes the following:

- Remains in the low-power monitoring mode
- User activates an invisible switch in case of an emergency
- The microcontroller detects the input signal
- GPS module obtains the present location data
- GSM module informs the contacts about the location
- Vibration motor acts as a response generator
- Switches off when the job is done

Hardware Components:

Lithium-Ion 18500 Battery:

Description of the 18500 Battery

The 18500 battery is a cylindrical and rechargeable lithium-ion battery. The battery diameter is usually about 18mm while the height of the battery is 50mm. The battery operates at a standard voltage of 3.7V and a maximum voltage of about 4.2V when charged.

The capacity of the battery usually varies between 1200mAh and 2000 mAh. This makes the battery ideal for powering small electronic equipment such as flashlights and personal electronics. The battery is also rechargeable hence can undergo several charge and discharge cycles.

Due to its high energy density and reliability, the battery is popular in powering low power electronic devices. Caution should be taken when handling the battery since the battery can pose danger when it is overcharged and fully discharged.

Fig 3.6.1: Lithium-Ion 18500 Battery

Arduino UNO R3:

The Arduino UNO R3 board represents a famous microcontroller system which is quite convenient for newbies and prototyping. This board contains the ATmega328P microcontroller and the ATmega16U2 chip providing the possibility of connecting the board to USB.

Moreover, it works at the frequency of 16 Mhz having 32 KB Flash memory, 2 KB SRAM, and 1 KB EEPROM as well as Power-On Reset and Brown-Out Detection functions.

In addition, there are many additional features in the board, such as timers, USART (Universal Synchronous/Asynchronous Receive/Transmit interface), SPI interface, I2C interface, analog comparator, watchdog timer, and six PWM (Pulse Width Modulation) channels.

It can support digital and analog input/output signals as well as process interrupts. It works with 2.7V-5.5V voltage and, therefore, it can be successfully applied for different applications in the field of IoT and embedded systems.

GPS Module (NEO-6M):

GPS Module – This particular module helps to provide the exact location of the user at any given point in time. It communicates with the microcontroller through a serial communication process, giving vital data such as latitude, longitude, and timing for emergency alerts.

Fig 3.6.2: GPS Module (NEO-6M)

Vibration Sensor Module (SW-420): The SW-420 is a tiny sensor that can sense vibrations and any form of shocks on the surface in a range of up to 3G. Its working voltage is within the range of 3.3V to 5V.

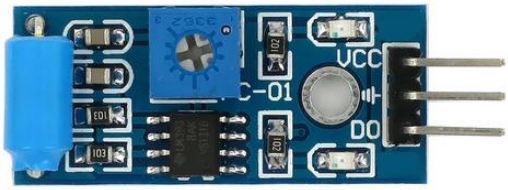


Fig 3.6.3: Vibration Sensor Module (SW-420)

Working Principle:

This particular module has two things; one is the vibration switch and other is the LM393 comparator circuit. As soon as it receives vibration, it causes the internal spring to make contact with another part, thereby causing an

electrical impulse to produce. It compares this impulse with a fixed level using the comparator. The digital output will go high only if the impulse exceeds this level; otherwise, it will remain low.

Characteristics:

The sensor consumes very little amount of current (about 15 mA) in operation. In addition to this, its sensitivity can be adjusted via a potentiometer and it also provides LED outputs. Furthermore, it is tiny and cheap and easy to interface with any embedded system.

Pin Configuration:

Usually the module has pins like VCC, GND, and D0 for the digital output, while some modules may also include A0 for analog output

SIM800L GSM Module:

The SIM800L is a compact GSM modem that assists the microcontroller in sending text messages, placing calls, and establishing a network connection through GPRS technology. The SIM800L operates within the standard cellular network, allowing users to communicate via standard mobile bands. This device will be employed for sending warning messages to specified phone numbers.

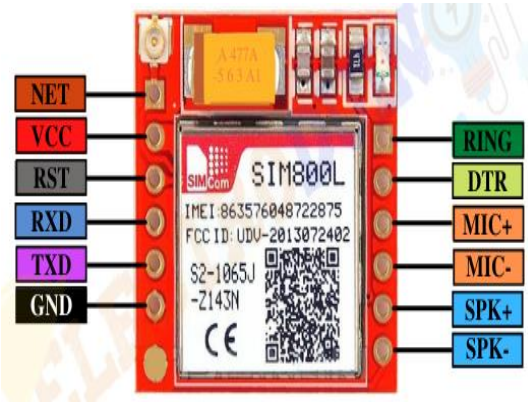


Fig 3.6.4: SIM800L GSM Module

Pin Number	Pin Name	Description
1	NET	External antenna attachment pin
2	VCC	Power supply pin, 3.4V to 4.4V input
3	RST	Reset pin, pull low for 100ms to perform hard reset
4	RXD	Serial data input
5	TXD	Serial data output
6	GND	Module ground reference
7, 8	SPK	Speaker differential output
9, 10	MIC	Microphone differential input
11	DTR	Serial data terminal ready pin, pull high to enable sleep mode
12	RING	Interrupt output, active low

Charger Module

Fig 3.6.5: Charger Module

Function: To provide sufficient power management for charging the batteries. We have designed the device which is battery operated. The TP4056 is a complete constant-current/constant-voltage linear charger for single-cell lithium-ion batteries.

Technical Specifications:

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{CC}	Input Supply Voltage		●	4.0	5	8.0	V
I_{CC}	Input Supply Current	Charge Mode, R_{PROG} = 1.2k	●		150	500	μA
		StandbyMode(Charge Terminated)	●		55	100	μA
		Shutdown Mode (R_{PROG} Not Connected,V_{CC} < V_{BAT}, or V_{CC} < V_{UV})	●		55	100	μA
V_{FLOAL}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃, I_{BAT}=40mA		4.137	4.2	4.263	V
I_{BAT}	BAT Pin Current	R_{PROG} = 2.4k, Current Mode	●	450	500	550	mA
	Text condition:VBAT=4.0V	R_{PROG} = 1.2k, Current Mode	●	950	1000	1050	mA
		Standby Mode, V_{BAT} = 4.2V	●	0	−2.5	−6	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT}<V_{TRIKL}, R_{PROG}=1.2K	●	120	130	140	mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG}=1.2K, V_{BAT} Rising		2.8	2.9	3.0	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{PROG}=1.2K		60	80	100	mV
T_{LIM}	Junction Temperature in Constant Temperature Mode				145		℃

MPU-6050 Accelerometer & Gyroscope Sensor:

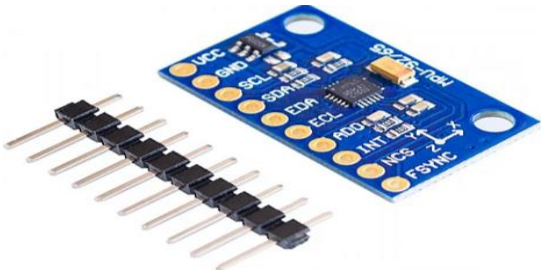


Fig 3.6.6: MPU-6050 Accelerometer & Gyroscope Sensor

The MPU-6050 is a popular 6-axis MEMS motion-tracking device that combines:

3-axis accelerometer

3-axis gyroscope

It also includes an internal Digital Motion Processor (DMP) capable of performing complex motion computations.

Relay Module

A relay module is an electronic device that consists of one or more relays (electromagnetic switches) and

associated components like transistors, diodes, and resistors on a single board. Relays are used to control high-voltage devices or systems using low-voltage microcontrollers or digital circuits. Here is some information about relay modules:

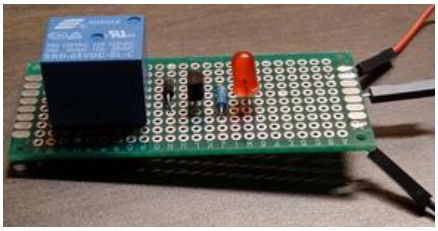


Fig 3.6.7: Relay Module

Relay Basics:

A relay is an electromechanical switch that uses an electromagnetic coil to open or close its contacts.

It allows low-power electronic circuits to control high-power devices or systems.

Voltage and Current Ratings:

Relay modules come in various voltage and current ratings. It's important to choose a relay module that matches the specifications of the devices you intend to control.

Connection to Microcontrollers:

Relay modules are usually controlled by digital signals from microcontrollers.

The low-voltage control signals energize the relay, which, in turn, switches the high-voltage circuit.

Precautions:

Be cautious of the voltage and current ratings to avoid damaging the relay module or connected devices.

Use protective measures like diodes to handle voltage spikes generated during relay operation.

Relay Module Components:

Relays: The heart of the module, which includes the electromagnetic coil and the switch contacts.

Driver Circuit: Typically includes transistors and sometimes optocouplers to interface with low-voltage control signals (like those from a microcontroller).

Protective Diodes: Used to suppress voltage spikes generated when the relay coil is turned off, protecting the other components.

Status LEDs: Indicate the status of the relay (whether it's energized or not).

Analytical & Mathematical Design

Model fall detection using threshold and time-window logic: detect spike when $\sqrt{(ax^2+ay^2+az^2)} > Athresh$ then check inactivity when $variance(\sqrt{(ax^2+ay^2+az^2)}) < Vthreshold$ for t_inactive seconds.

Model double-tap as two impact events with magnitudes above Itap separated by $\Delta t \leq Tmax\_tap$.

Estimate GPS position uncertainty using HDOP and use weighted average of last N fixes to reduce noise: $lat\_est = \Sigma(lat\_i/\sigma\_i^2)/\Sigma(1/\sigma\_i^2)$.

Calculate message send latency L = Tprep + Tgsm + Tack and use worst-case GSM current spike Ipeak to size power components.

Battery runtime approximation R = (Capacity * η) / (Istandby + p_event * Iavg_event) where p_event is event probability per hour.

Set detection thresholds and timing parameters via receiver operating characteristic analysis to balance false

positive and false negative rates.

Design margin by applying safety factors to current and voltage calculations to handle GSM peak draws and temperature variations.

Sim 800 L

Conventions and abbreviations

The GSM engines are referred to as following term:

ME (Mobile Equipment);

MS (Mobile Station);

TA (Terminal Adapter);

DCE (Data Communication Equipment) or facsimile DCE (FAX modem, FAX board);

In application, controlling device controls the GSM engine by sending AT Command via its serial interface.

The controlling device at the other end of the serial line is referred to as following term:

TE (Terminal Equipment);

DTE (Data Terminal Equipment) or plainly "the application" which is running on an embedded system, AT Command syntax:

The "AT" or "at" or “at” or “At “prefix must be set at the beginning of each Command line. To

terminate a Command line enter <CR>.

Commands are usually followed by a response that includes.

"<CR><LF><response><CR><LF>"

Throughout this document, only the responses are presented, <CR><LF> are omitted intentionally.

The AT Command set implemented by SIM800 Series is a combination of 3GPP TS 27.005,

3GPP TS 27.007 and ITU-T recommendation V.25ter and the AT commands developed by

Basic syntax

These AT commands have the format of "AT<x><n>", or "AT&<x><n>", where "<x>"is the Command, and "<n>"is/are the argument(s) for that Command. An example of this is "ATE<n>", which tells the DCE whether received characters should be echoed back to the DTE according to the value of "<n>". "<n>" is optional and a default will be used if missing.

S Parameter syntax

These AT commands have the format of "ATS<n>=<m>", where "<n>" is the index of the S

register to set, and "<m>"is the value to assign to it. "<m>" is optional; if it is missing, then a default value is assignee.

Result and Discussion

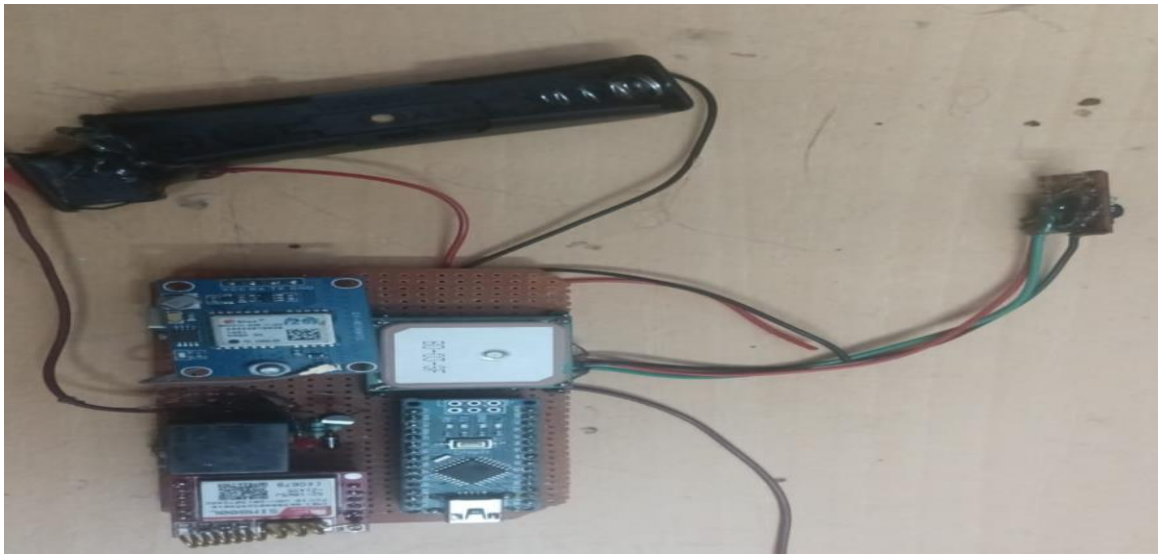


Fig. 5: Hardware

Conclusion

Our prototype includes the following features – GPS, GSM, accelerometer, motion sensors and push button activation. All of these devices combined together form an efficient mini emergency alerting system. In test condition our device proved its efficiency in gathering location data using GPS in an open field and sending the information through SMS to desired recipients.

With the help of accelerometer our system can detect an accidental fall by detecting a shock followed by the complete stop of motion activity. Our fall detection algorithm can distinguish between the occurrence of a fall and any kind of regular activity like sitting and walking. By adding a double tap sensor feature we have prevented accidental activation and made it easy for the victim to turn on the system using the hidden button. Once the button was pushed, the system activated in less than a second, ensuring the promptness of sending SMS alerts. Although depending on conditions messages transmission speed can differ while using the GSM module, tests proved the reliability and promptness of this process.

In conclusion we would like to state that our test showed that this device works efficiently, reacts instantly, uses minimal energy resources and sends messages with the least delay possible. All these facts prove that it could be used effectively in real life situations having low false alarm ratio.

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