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GPS BASED HUMAN TRACKING AND SOS SENSING SYSTEM

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ABSTRACT

Nowadays the number of road accidents has increased at an unprecedented rate. Many a time road accidents occur at places where help does not reach immediately. An important reason for this delay may be that information about the accident reaches the concerned people or authorities very late or does not reach at all. Delay in reaching help at accident sites might cause the loss of human life.

India’s roads are a dangerous mix of high-speed cars, run-down vehicles, inadequate infrastructure, unskilled drivers and other vulnerable road users. According to WHO statistics (2009), our country loses more than 100 000 lives due to road traffic crashes every year. It has a road traffic fatality rate of 16.8 deaths per 100,000 population. Approximately half of all deaths on the country's roads are among vulnerable road users - motorcyclists, pedestrians and cyclists. According to the recently published WHO Global Status Report on Road Safety, though there are laws on speed, seatbelt wearing and helmet wearing, and drink-driving, they are poorly enforced.

To ameliorate the fatalities stemming from accidents a device has been developed which would send an emergency message along with the location of the site using the GSM and GPS system embedded in it. The device will be set to sense an emergency by measuring any drop/sharp rise in the pulse rate and/or by detecting shock waves in case of an accident. Along with the location coordinates, the idea is to send the pulse rate information of the user. The device would also call an emergency contact number specified by the user. This device could also be used for safety purpose in the sense that it would send an emergency message and along with its location on an emergency helpline number so that nobody is left unattended.

INTRODUCTION

A location and tracking system becomes very important to our future world of pervasive computing. A system for tracking a human's mobility using two technologies viz Global Positioning System (GPS) and Global System for Mobile Communications (GSM) is designed to serve our purpose. A GPS tracking unit is a device which exploits the use of Global Positioning System to determine the location of a vehicle, person, or other asset to which it is attached and to record the position of the asset at regular intervals. A GPS tracker essentially contains GPS module to receive the GPS signal and calculate the coordinates. For data loggers it contains large memory to store the coordinates, data pushers additionally contains the GSM/GPRS modem to transmit this information to a central computer either via SMS or via GPRS in form of IP packets.

GPS tracking devices such as the SPOT Satellite Messenger are available that allow friends, family, and rescue personnel to track the position of a person and receive messages from them, even when the user of the device is outside of cellular range. GPS handled tracking devices with built-in cell phone are used to monitor the employees by various companies, especially the employees which are engaged in field work job. An arrested suspect out on bail may have to wear a GPS tracker, usually an ankle monitor, as a bail condition.

Hybrid positioning systems are systems for finding the location of a mobile device using several different positioning technologies. Usually GPS (Global Positioning System) is one major component of such systems, combined with cell tower signals, wireless internet signals, Bluetooth sensors, IP addresses and network environment data, or other local Positioning Systems. These systems are specifically designed to overcome the limitations of GPS, which is very exact in open areas, but works poorly indoors or between tall buildings (the urban canyon effect). By comparison, cell tower signals are not hindered by buildings or bad weather, but usually provide less precise positioning. Wi-Fi positioning systems may give very exact positioning, in urban areas with high Wi-Fi density - and depend on a comprehensive database of Wi-Fi access points.

In August 2010, a Brazilian company Unilever ran a promotion where GPS trackers were placed in boxes of Omo laundry detergent. Teams would then track consumers who purchased the boxes of detergent to their homes where they would be awarded with a prize for their purchase. The company also launched a website (in Portuguese) to show the approximate location of the winners' homes.

GSM (Global System for Mobile Communications, originally Group Spécial Mobile), is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones. It became the de facto global standard for mobile communications with over 80% market share. The GSM standard was developed as a replacement for first generation (1G) analog cellular networks, and originally described a digital, circuit-switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit-switched transport, then packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS).

SIM908

SIM908 module is a complete Quad-Band GSM/GPRS module with the combination of GPS technology to sense location and other satellite-based information. This compact design reduces power consumption and is easy to operate as it is AT command compatible. GPS based applications can be designed, with great efficiency, using SIM908 module.

With a tiny configuration of 50 mm x 33 mm x 8.8 mm, SIM908 can meet almost all the space requirements in user applications, such as M2M, smart phones PDA, tracker and other mobile devices. SIM908 has a 60-pin connector, which provides an interface between the module and other customised circuit boards.

Salient features of SIM908 module are mentioned below:

- Operates in a voltage range of 3.2V -4.8V
- Supports charging control for Li-Ion battery
- Supports 1200bps to 115200 bps of transfer rate through serial communication.
- AT command compatible
- Two audio channels: two audio inputs and two audio outputs
- Programmable general purpose input and output
- RF connector interface
- Flexibility to develop customised applications through keypad and SPI display.
- SIM908 integrates TCP/IP protocol and extended TCP/IP AT commands used extensively in data transfer applications
- Current consumption is as low as 1 mA in sleep mode.
- Supports Real Time Clock
- Supports SIM card: 1.8V, 3V

The GSM/GPS shield used in the module has antennae for GPS, a modem and a jumper that connects the SIM card to the Serial pins; RX and TX to facilitate serial communication. SIM908 module is placed at the rear end of the shield (see Figure 1).

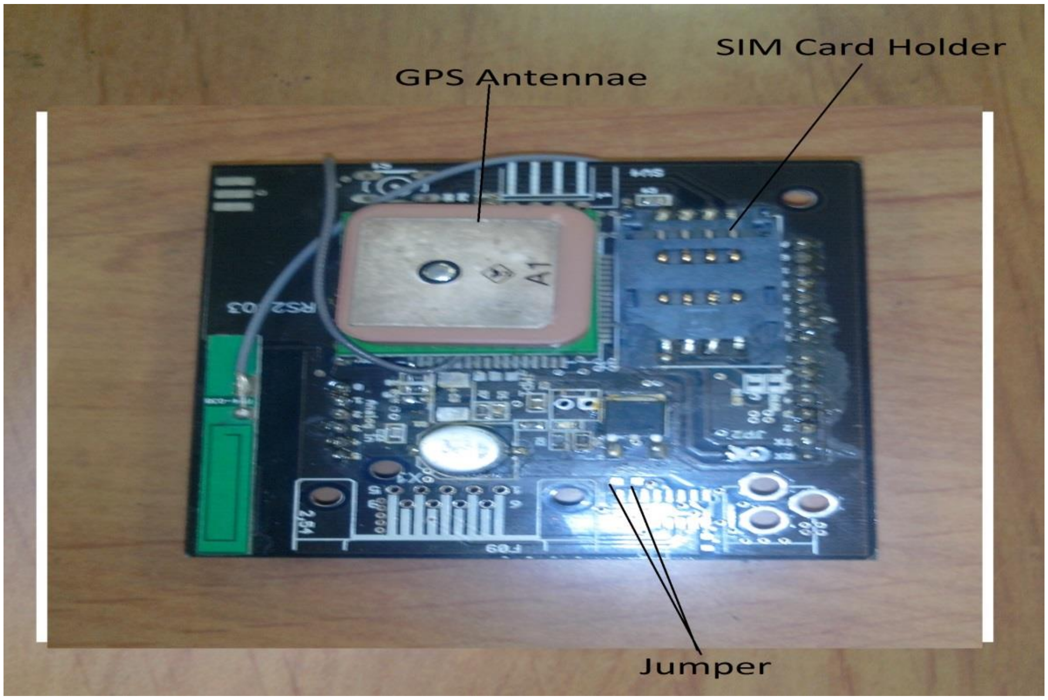


Figure 1: SIM908 module

ARDUINO

Arduino is an open-source electronic prototyping platform that provides a flexible, easy to use hardware and software, used extensively in the development of small to very large modules. The Arduino Development Environment provides an excellent platform for writing instructions and uploading them directly onto the ATMEGA chip that further controls the other hardware components on Arduino board.

There are different types of Arduino prototyping boards available in the market, such as Arduino Mega, Arduino Deumilanove, Arduino Uno, Arduino Nano, Arduino Leonardo etc. Arduino Uno has been used as the prototyping board for the device developed by us. The Uno is the latest in the series of USB Arduino boards.

Arduino UNO (Source: http://arduino.cc/)

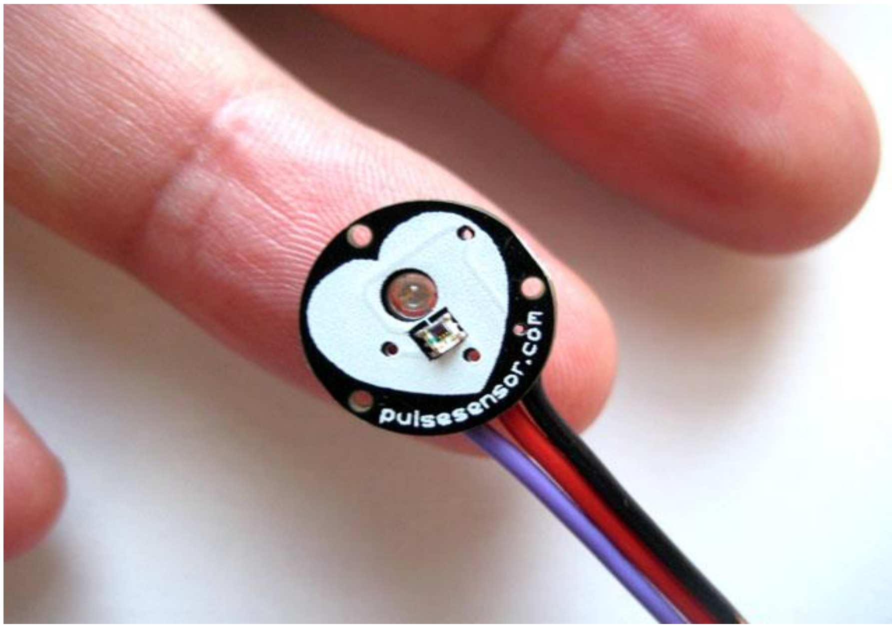
It is based on ATmega328. The main components on Uno microcontroller board are:

- 14 digital input/output pins (6 of these could be used as PWM pins)
- 6 analog input pins
- 16 MHz ceramic crystal
- An ICSP header
- A USB connection
- A power jack
- A reset button

The board has a flash memory of 32 KB of which 0.5 KB is reserved for boot loader.
SRAM size is 2 KB and EEPROM size is 1 KB.

PULSE RATE SENSOR

Pulse Sensor makes pulse measurement very simple. It is a well-designed plug-and-play heart-rate sensor for Arduino. The sensor clips onto a fingertip or earlobe and plugs right into Arduino. It is a greatly improved version of the original pulse sensor. This version of pulse rate sensor incorporates amplification and noise cancellation circuitry into the hardware, making it much more reliable. It is compatible to 3.3 and 5V microcontrollers.



Pulse Rate Sensor (Source: http://www.pulsesensor.com/)

The Pulse Rate Sensor contains a 24-inch Color-Coded Cable, with (male) header connectors. An Ear Clip, perfectly sized to the sensor, is used to connect the sensor to the earlobe. If the sensor has to be connected to the finger, Velcro strips are used for the purpose. Velcro dots have to be attached at the top of the sensor, to facilitate attachment with Velcro strips. The sensor should be hot- glued at the back, for safety.
Transparent stickers are used on the front of the Pulse Sensor to protect it from oily fingers and sweaty earlobes. The Pulse Rate Sensor has 3 holes around the outside edge which make it easy to sew it into almost anything. It measures subtle changes in light from expansion of the capillary blood vessels to sense the heartbeat.

BATTERY

A lithium-ion battery (sometimes Li-ion battery or LIB) a member of a family of rechargeable battery types in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. Li-ion batteries use an intercalated lithium compound as the electrode material, compared to the metallic lithium used in non-rechargeable lithium battery. A 12V (1000mAh) Li-ion battery with 1C discharge is used to power the GSM/GPS module.

SETUP

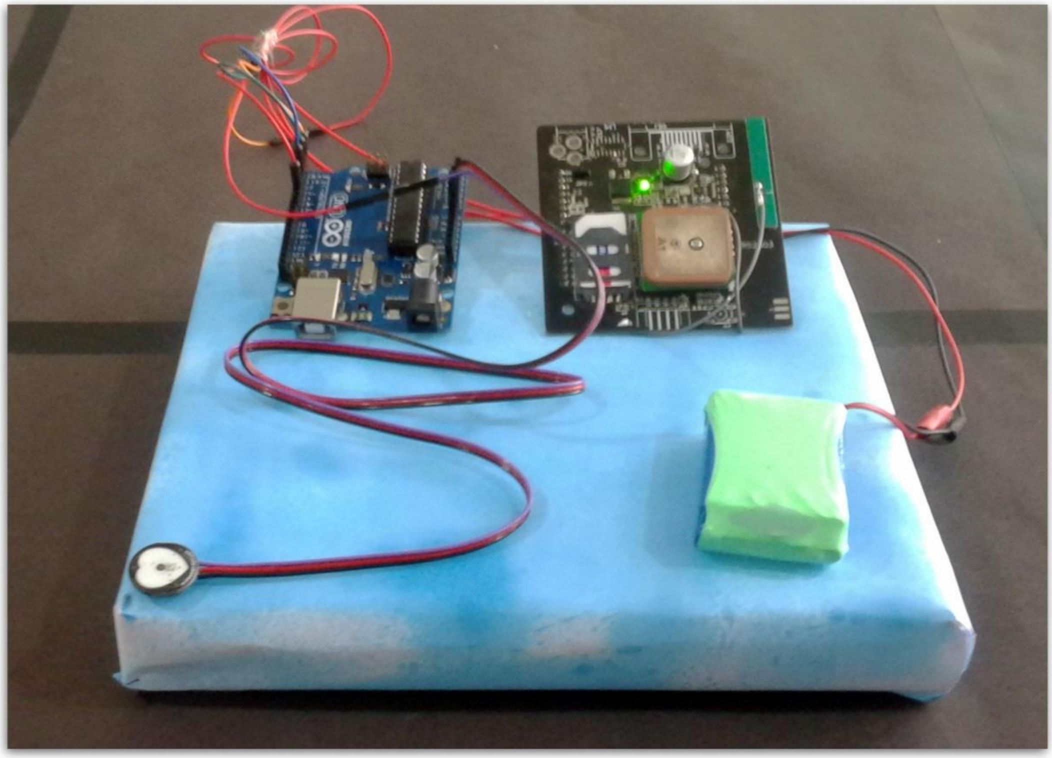


Figure 2: Complete Module

The setup consists of the GSM/GPS SIM908 module connected to Arduino Uno circuit board, through RX and TX pins of Arduino. The Arduino board is powered with a 12 V supply. The GSM/GPS module also requires a separate power supply of 12 V, and this requirement is fulfilled by a 12V Lithium ion battery. Digital pin 5 of Arduino (connected to digital pin 5 of the module) has been used to configure the module to the network. A LOW logic value is given as output from digital pin 5 of the Arduino board and subsequently, as an input to digital pin 5 of the module, for about 1 second, after which logic value HIGH is fed to pin number 5, which persists thereafter. This process registers the GSM/GPS module to the GSM network.

The pulse rate sensor has been connected to the digital pin 2 of the Arduino Uno board. Digital pins 2 and 3 support interrupt that has to be generated after every pulse and the pulse count recorded, so that pulse rate could be obtained at the end of every minute. Microcontroller on the Arduino board constantly monitors the pulse rate of the user. If the pulse rate falls below the threshold level or rises beyond the upper limit, then the SIM908 module is activated and it sends the emergency message, along with its location, on an emergency number specified by the user.

REGISTERING TO THE GSM NETWORK

As explained earlier, the GSM/GPS module has a slot that holds the SIM card. For the module to send SMS, the SIM card must be registered to the Home Location Register (HLR) i.e., it must have a billing relationship to some operator .After the module if switched on, the SIM card searches for the nearest Base Transceiver Station with the strongest signal in the operator's frequency band. Once the BTS has been in detected, the SIM card identifies itself to the network through the control channel. Once accomplished, the phone is said to be registered.

SIM908 module is AT command compatible .Commands used for network registration are AT and AT+CREG. AT command is used to control the modem and AT +CREG command gives information about the registration status and access technology of the serving cell .AT+CREG 01 is used to check if the SIM card has been registered to the Visitor Location Registry and consecutively to the Home Location Register whereas AT+CREG 05 checks if the SIM card is registered as roaming entity in the Visitor Location Register.

SENDING MESSAGE THROUGH THE MODULE

Once registered, AT+CMGF command is used to set the sim card to the SMS mode. If AT+CMGF command returns 1, SMS mode is set. AT+CMGS command is used to send SMS to the specified number.

REGISTERING TO THE GPS NETWORK AND GETTING CURRENT LOCATION OF THE MODULE

The module takes four to five minutes to register to the GPS network. The receiver passively receives satellite signals and requires an unobstructed view of the sky. GPS operations depend on a very accurate time reference, which is provided by atomic clocks on board the satellites.

Each GPS satellite transmits data that indicates its location and the current time. All GPS satellites synchronize operations so that these repeating signals are transmitted at the same instant. The signals, moving at the speed of light, arrive at a GPS receiver at slightly different times because some satellites are further away than others. There are at least 24 operational GPS satellites along with some spare satellites.

GPS satellites transmit two radio signals. These are designated as L1 and L2. A Civilian GPS uses the L1 signal frequency (1575.42 MHz) in the UHF band.

The GPS signal contains three different bits of information — a **pseudo random code**, **almanac data** and **ephemeris data**.

The **pseudo random code** is simply an I. D. code that identifies which satellite is transmitting information. You can often view this number on your GPS unit's satellite information page; the number attached to each signal bar identifies which satellites it's receiving a signal from.

Almanac data is data that describes the orbital courses of the satellites. Every satellite will broadcast almanac data for every satellite. The GPS receiver uses this data to determine which satellites it expects to see in the local sky. It can then determine which satellites it should track. With Almanac data the receiver can concentrate on those satellites it can see and forget about those that would be over the horizon and out of view. Almanac data is not precise and can be valid for many months.

Ephemeris data is data that tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite will broadcast its OWN ephemeris data showing the orbital information for that satellite only. Because ephemeris data is very precise orbital and clock correction data necessary for precise positioning, its validity is much shorter. It is broadcast in three six second blocks repeated every 30 seconds. The data is considered valid for up to 4 hours. Its accuracy, however, decreases after 2 hours

All GPS satellites have several atomic clocks. The signal that is sent out is a random sequence, each part of which is different from every other, called pseudo-random code.

This random sequence is repeated continuously. All GPS receivers know this sequence and repeat it internally. Therefore, satellites and the receivers must be in synch. The receiver picks up the satellite's transmission and compares the incoming signal to its own internal signal. By comparing how much the satellite signal is lagging, the travel time becomes known.

If the travel time of the signal is known, then having known the speed of the signal, the distance of the satellite from the receiver could be determined. At least six satellites are located by the GPS device at a time. Then, taking each satellite as centre, an imaginary sphere is drawn such that the device is at the periphery of the sphere. In this manner, six spheres could be drawn and they would intersect at a common point, i.e. the receiver. Thus, the location of the receiver could be tracked.

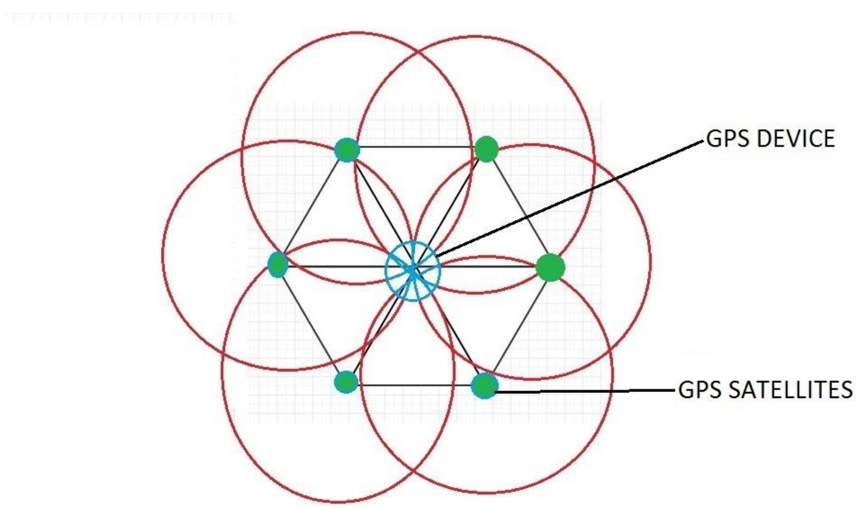


Figure 3: GPS network for location

To compute a PVT (position velocity time) solution the receiver will look for satellites based on where it 'thinks' it is roughly located and the almanac if current. If it finds one or more of the satellites it expects to see it will lock onto that satellite and begin downloading ephemeris data. Once data from six satellites has been received an accurate positional fix is calculated.

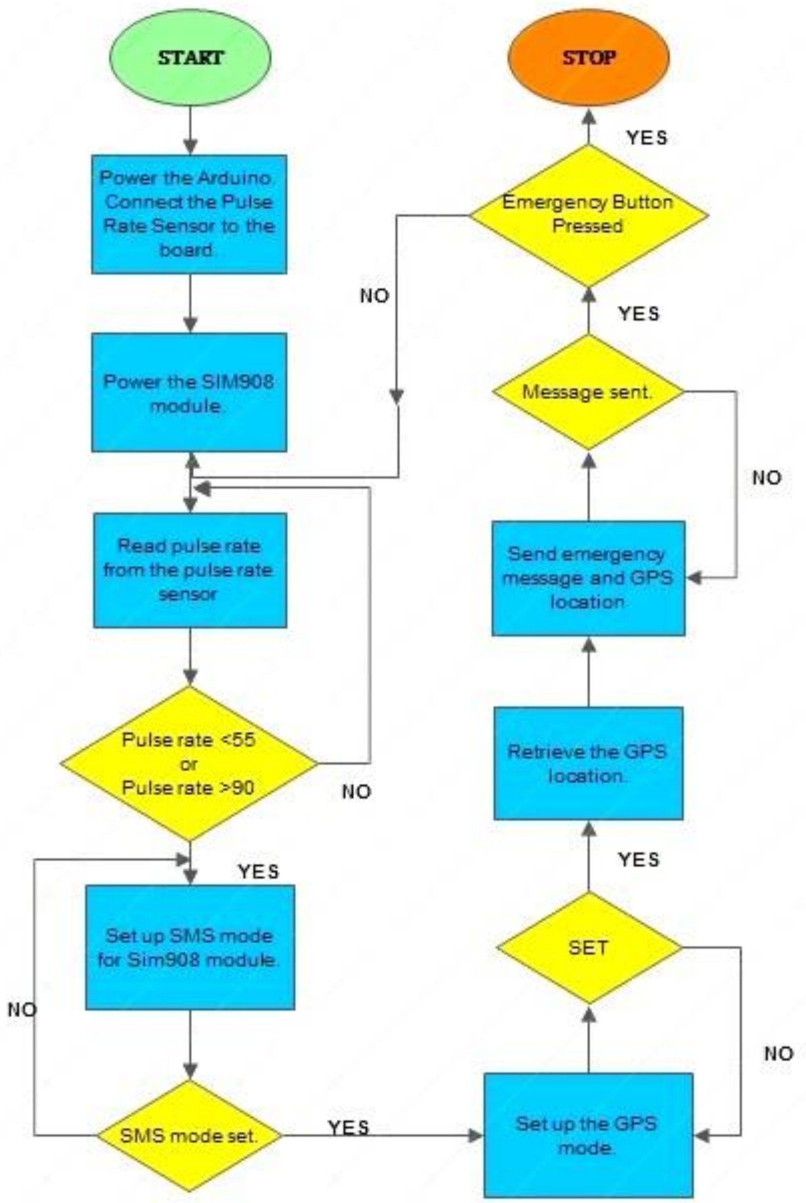
The receiver must complete reception of ephemeris data without error, this data is transmitted in packets. Should any one packet not be received completely without error then it must start over again. Clearly doing this whilst moving lead to much higher error rates and longer fix times. Therefore, the receiver would take more time in downloading ephemeris data while moving less than a second of interruption is enough to mean the receiver will have to wait for the next transmission.

The developed module uses AT+CGPSPWR command to power the GPS module. AT+CGPSPWR=1 command switches on the GPS device and AT+CGPSPWR=0 switches off the GPS device. AT+CGPSRST=1 command is used to reset the GPS device in autonomy mode.

AT+CGPSIPR command sets the port speed on the NMEA output serial interface. The rates that can be set are 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800, ATSO=3 command instructs the modem to answer on the third ring.

AT+CMGDA command is used to delete the SMS from the SIM908 memory. AT+CGPSSTATUS command is used to return the status of the GPS. AT+CGPSSTATUS=1 means GPS network has been established whereas AT+CGPSSTATUS=0 means GPS network has not been registered. AT+CGPSINF command returns the current GPS location information.

FLOW CHART


START
STOP
YES
Power the Arduino. Connect the Pulse Rate Sensor to the board.
Emergency Button Pressed
NO
YES
Power the SIM908 module.
Message sent.
NO
Read pulse rate from the pulse rate sensor
Send emergency message and GPS location
Pulse rate <55 or Pulse rate >90
NO
Retrieve the GPS location.
YES
YES
Set up SMS mode for Sim908 module.
SET
NO
NO
SMS mode set.
YES
Set up the GPS mode.

PSEUDO CODE

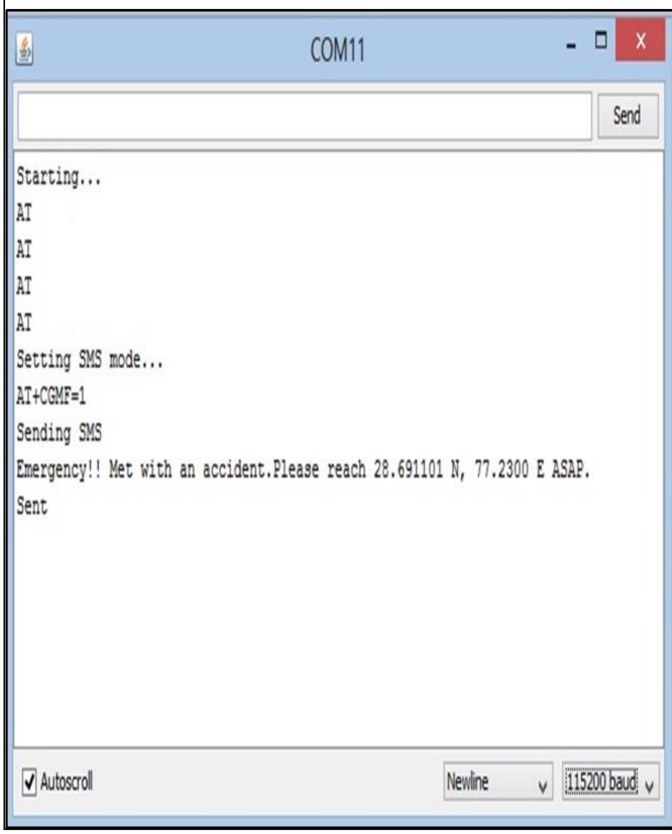
```
Function SMS_GPS_SEND():
Set timer for ATMEGA328;
Count=0   //counts the number of pulses in a second
Val=0
while(1)
      Val=analogRead(analogPin)    //read analog data from the pulse rate sensor
           if timer equals 60000 then  //time measured in mili seconds
               return count
               if count<55 OR count>90 then
                        call function SMS_Location()  //send message and GPS location
               end if
              Reset timer=0;
              Reset count=0;
         else
              count=count+1;
        end if
end while

function SMS_Location()    //function to send SMS and GPS  location on an emergency number
         set pin_module to LOW for 1 second
         set pin_module to HIGH
         if Time t< tth (threshold time)      //checks if time runs out
              if network_register=High:
                  set SMS_mode to High;
                   loc= GPS_Location;     //returns GPS location of the device
                  SMS="Message"+"loc"   //Concatenates emergency message and GPS location in the SMS
                  Send SMS using AT+CMGF
                    if  sent  then
                      Print "Sent"
                   else
                      Print "Message not sent"
                     recall function SMS_Location()
                  end if
             else  recall function SMS_Location
        end if
```

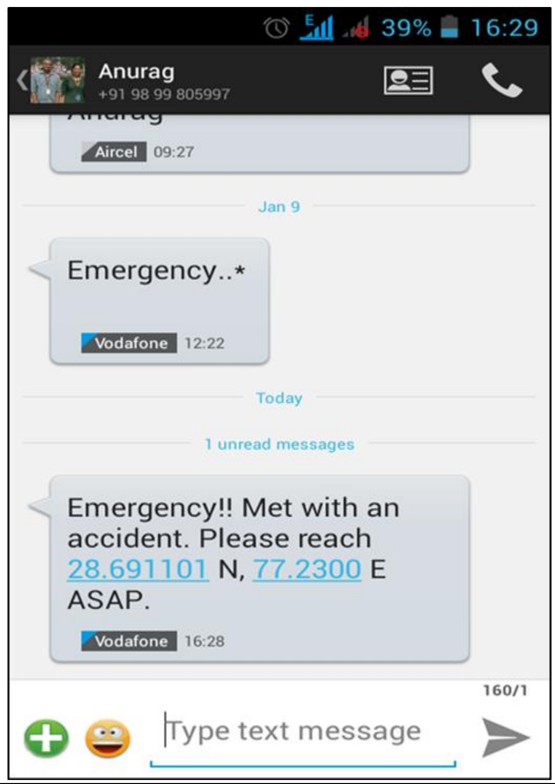
RESULT

The module takes about 30 seconds to register to the GSM network and 30 seconds to register to the GPS network. It sends an emergency message, along with the latitude and longitude of the module.

ARDUINO 1.0.5 IDE



Message Received on Cell Phone



FUTURE WORK

1. Use of Arduino Nano to minimize the size of the module.
2. Incorporation of vibration sensors and charging of the battery using vibrations.
3. Charging the module using solar power.
4. Depiction of latitudes and longitudes on Google maps so that locating the accident site becomes easy.
5. Incorporation of an external antenna to improve the response of the module.

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