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DEVELOPMENT OF INTELLIGENT TRACKING DEVICE FOR DEMENTIA AFFECTED PERSONS

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ABSTRACT

Dementia is characterized by the loss of one's memory and cognition. Patients with dementia often wander away from their homes without being aware of it, creating difficulty to the care givers in locating them. In this paper, Intelligent tracking device has been developed to primarily help dementia affected persons keeping in touch with their family and care givers. The device can be equally useful in the search and rescue of people with dementia who have lost their way. The device employs GPS and GSM technologies to track the location of a dementia patient and to communicate it, respectively. The GPS module is used to extract the location by linking itself to satellite. GSM modem is used for global range wireless communication. The system development process is divided into two; hardware development and software development. Hardware development includes testing of all the individual modules: GPS receiver, GSM Modem, LCD, keypad with emergency push button and integrating them in to a complete system. Software development started with flow charts of main program and interrupt service routing. It includes writing program code for the microcontroller, testing and debugging it, then simulating the system on Proteus software and finally loading the program code in to the microcontroller. The hardware and software are integrated to form the complete system. The system functionalities have been tested individually. The system can successfully read the data from GPS receiver and display it on LCD and also send the data via GSM.

1. INTRODUCTION

Dementia is a syndrome usually of a chronic or progressive nature in which there is deterioration in cognitive function (i.e. the ability to process thought) beyond what might be expected from normal ageing. It affects memory, thinking, orientation, comprehension, calculation, learning capacity, language, and judgement[1].

Wandering is one of the most common, complex, burdensome and costly behaviours of dementia diseases. Every person with dementia who can walk as well as those who continue to drive is at risk of becoming lost. Beyond directly impacting the

person with dementia, this behaviour poses widespread implications for other sectors, especially family caregivers and healthcare professionals. Patients with dementia also forget the telephone numbers of their care givers and normal telephones are very complicated for their regular use. This in turn puts them at risk during emergency situation where they would struggle to communicate. Hence, this Intelligent Tracking Device is developed to help dementia affected persons keeping in touch with their family and care givers. It helps in the search and rescue of people with dementia who have lost their way.

The proposed system employs GPS and GSM technologies to track the location of a dementia patient and to communicate it, respectively. The GPS module is used to extract the location by linking itself to the satellite. GSM modem is used for global range wireless communication. The system development comprises of hardware and software development. Hardware development that includes testing of all the individual modules and integrating them in to a complete system and Software development which starts with flow charts of main program and interrupt service routing, and includes writing program code for the microcontroller, simulating the system on Proteus software and finally loading the program code in to the microcontroller.

2. RELATED WORK

Real-time tracking and management of object, vehicle, persons, or other assets has been a field of interest for many researchers and a lot of research work has been done for tracking system.

GPS walker for elderly is designed by group of student researchers in Arnhem Nijmegen University. The GPS walker has been tested on some patients of nursing homes. The system was particularly aimed at people with amnesia or orientation problems. The researchers aimed to avoid the common incidence of dementia patients getting lost even within their old houses. The instructions for GPS walker are easy to invoke, there are just five different buttons each intended for a different use. Once the user presses a button on the device the walker points out the way, for instance push of a coffee button tells the way to the restaurant[2].

Mimas Pro is a GPS tracking device which enables to call for help with a single push button. When the alarm button is pressed an alarming SMS is sent to predefined receiver and they can communicate. This device is made of just using GSM mobile phone technology. Movement detector is used for sending an alarm if the user has been immobile for long time[3].

Fleischer, P.B.; et al describe development and deployment of GPS (Global Positioning System)/GSM (Global System for Mobile

Communications) based Vehicle Tracking and Alert System. This system allows inter-city transport companies to track their vehicles in real-time and provides security from armed robbery and accident occurrences [4].

Everon manufacturer introduced a new GPS bracelet for dementia patient named Vega. This device is made up of GPS receiver, GSM, and RF tag. One of its unique features that distinguish it from other tracking devices is that the specific area zone can be defined in which patient can walk. If patient goes outside that zone then automatic alarming signal is generated for caretaker. Also online monitoring is possible via web, and caretaker can see the exact location of patient via GPS coordinates sent by the device through GSM to the Everon web server[5].

3. TECHNOLOGIES USED

For the development of intelligent tracking device for dementia affected persons in this paper, the following technologies are used:

3.1 GLOBAL POSITIONING SYSTEM (GPS) TECHNOLOGY

Global Positioning System (GPS) is the newly emerging tracking and route planning system is the Global Navigation Satellite System (GNSS) developed by the Department of Defence (DOD) of the United States. GPS is a satellite technology uses a constellation of between 24 and 32 Medium Earth Orbit satellites that transmit precise microwave signals that enable GPS receivers to determine their current location, the time, and their velocity. The GPS satellite constellation is managed by the United States Air Force 50th Space Wing.

GPS is widely used by non-military or public sector as a navigation system especially for vehicle tracking and navigation purposes. At present a GPS tracking unit is a device that is used to find the exact location of an object, vehicle, person, or other assets and records the position at regular intervals. All the positions are stored regularly and may be transmitted either to some central database location or send by Internet connection to the computers using General Packet Radio Service (GPRS). The accurate information can be extracted by available customized software or web services providers[6].

3.2 GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM) TECHNOLOGY

GSM technology is the world’s most popular standard for mobile phones. Currently more than three billion people across the 200+ countries are using this technology. GSM is 2G (Second Generation) technology while currently 3G (Third Generation) and 4G (4th Generation) technologies are also in used. GSM mobile phone provides several features including international roaming, SMS, and usage of Internet via GPRS.

GSM is an important part in designing of elderly care devices because it is the main communication channel between device and care taker of patients. In mobile phones and elderly care devices, a SIM (Subscriber Identity Module) card is inserted which contains the specific number and information of user. The use of GSM in case of elderly care is so that in emergency situations the alarm signal will be sent via SMS and some devices will be having voice support to talk to the patient directly[7].

4. PRINCIPLE OF OPERATION

Intelligent Tracking Device for Dementia Affected Persons employs GPS and GSM technologies to track the location of dementia person wearing it and also communicate the location’s longitude and latitude to either care giver or family member. ATMEGA 2560 Microcontroller serves as the heart of the system by controlling all the system’s

5. HARDWARE DEVELOPMENT

functionality. It receives the longitude and latitude data from GPS receiver via serial communication, display it on LCD and transmit them serially to GSM Modem. GSM Modem sends the data (coordinates) via SMS. A 4X4 matrix keypad is used to change the recipient data. A push button is used to enable data change function.

When the device is switched on “ITD-DAP System ready” appear on the LCD to tell the user system is ready. Here the user can change the recipient’s data by first pressing the “Data Change Enable Button” and then enter the data using keypad. Following options are available for users to get response from the device.

Option 1: Upon request from the care giver. When a call is made to the device, the location’s coordinates of the dementia patient wearing the device is sent to the user as an SMS alert.

Option 2: Periodically; an SMS containing the location’s data will be sent to the care giver. for every 30 minutes.

Option 3: In case of any emergency; when “Emergency Button” is pressed by the patient, an SMS will be sent containing the location of the patient.

The device carry a SIM card in the subscriber identity module attached to the GSM Modem. The location can be viewed on Google Map by inputting the coordinates.

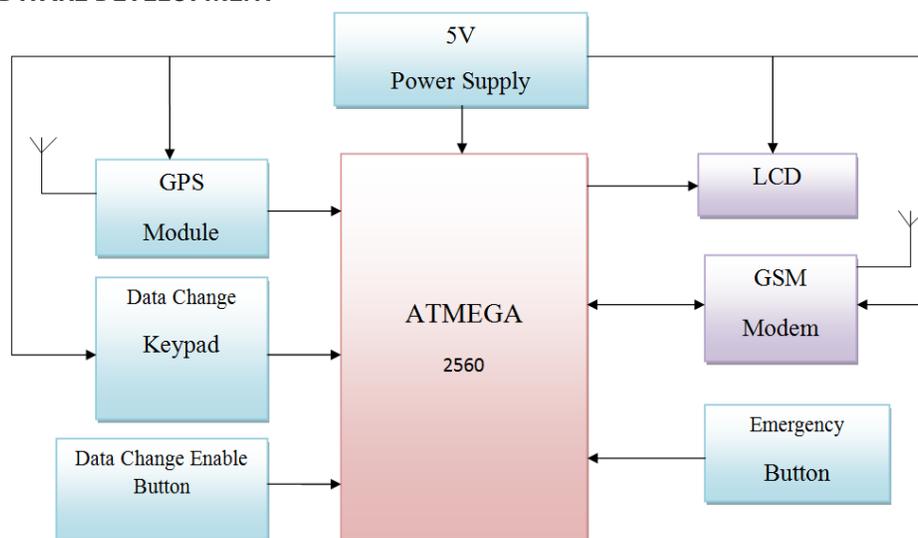


Figure 1: Block Diagram of Intelligent Tracking Device for Dementia Affected Persons

The block diagram shows the overall view of the Intelligent Tracking Device for Dementia Affected Persons hardware. The blocks connected to the microcontroller are LCD, GPS module, GSM modem, Keypad, Power supply, Emergency Button and Data change Enable Button.

5.1 POWER SUPPLY UNIT

The purpose of a power supply is to provide the required amount of power from primary source. The ARDUINO MEGA BOARD and GSM Modem are powered with a 12V AC-to-DC adapter, and all the remaining devices take their supply from either the microcontroller board or the GSM Modem.

5.2 ARDUINO MEGA (ATMEGA 2560) MICROCONTROLLER

ATMEGA 2560 Microcontroller serves as the heart of the system by controlling the system’s functionality. The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analogue inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; it can simply be connected to a computer with a USB cable or be powered with an AC-to-DC adapter or battery to start working[8].



Figure 2: Arduino Mega (ATMEGA 2560) [8]

5.3 INTERFACING GPS MODULE WITH MICROCONTROLLER

GPS receiver module detects the latitude and longitude of a particular position by linking itself to GPS satellite. The GPS receiver (

GPS_EM-410) used in this design can acquire GPS signals from 65 channels of satellites and output position data with high accuracy. The output is a serial data of 9600 baud rate in NMEA 0183 v3.0 protocol standard.

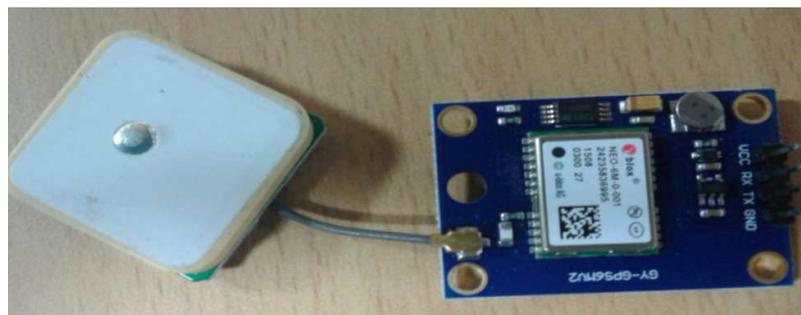


Figure 3: GPS Receiver Module (Original Picture)

The NMEA 0183 protocol covers a broad array of navigation data. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to this GPS

receiver. The NMEA message structure is described below.

Structure:
 \$GPGGA,hhmmss.sss,ddmm.mmmm,a,ddmm
 .mmmm,a,x,xx,x.x,x.x,M,,,,,xxxx*hh<CR><LF>

Example:

\$GPGGA,111636.932,2447.0949,N,12100.5223,E,
1,1,0.8,118.2,M,,,,,0000*02<CR><LF>

In this design the GPS receiver detects the location of the dementia affected persons and communicates them serially at 9600 baud rate

to the microcontroller. The transmitter pin of the GPS receiver is connected to the receiver pin (pin 19/Rx1) of the microcontroller. Fig. 4 Shows Connection between the GPS receiver module and microcontroller.

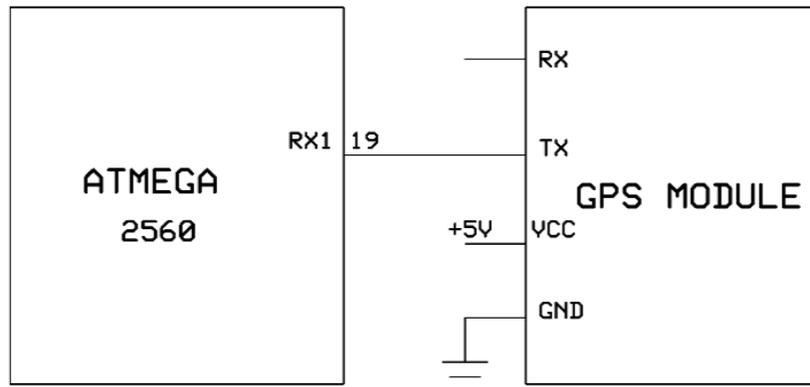


Figure 4: GPS Module-Microcontroller Interface

5.4 INTERFACING GSM MODEM WITH MICROCONTROLLER

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. GSM (Global system for mobile)

uses a process called circuit switching. This method of communication allows a path to be established between two devices. Once the two devices are connected, a constant stream of digital data is relayed.



Figure 5: GSM Modem (original picture)

This GSM Modem works on frequencies 850 MHZ, 900 MHZ, 1800MHZ and 1900 MHZ. It is designed with 3V3 and 5V DC TTL interfacing circuitry, which allows User to directly interface with 5V Microcontrollers (PIC, AVR, Arduino, 8051, etc.) as well as 3V3 Microcontrollers (ARM, ARM Cortex XX, etc.). The baud rate can be configurable from

9600-115200 bps through AT (Attention) commands. It has internal TCP/IP stack to enable users to connect with internet through GPRS feature. It is suitable for SMS as well as DATA transfer application in mobile phone to mobile phone interface. The modem can be interfaced with a Microcontroller using USART feature (serial communication)[9].

In this design the GSM modem is used to send a data containing the coordinates of the patient's position by SMS to the care giver. It is also used to received a call from the care giver requesting for the patient's coordinates. It is deigned tocommunicates with the microcontroller at 9600 baud rate. As per our requirements the transmitter pin of the GSM

Modem is connected to the receiver pin (pin 0/Rx0) of the microcontroller while the receiver pin of the modem is connected to transmitter pin (pin 1/Tx0) of the microcontroller. A +5V is connected to VCC pin of the Modem. Connections between the GSM Modem and microcontroller are shown in Fig. 6.

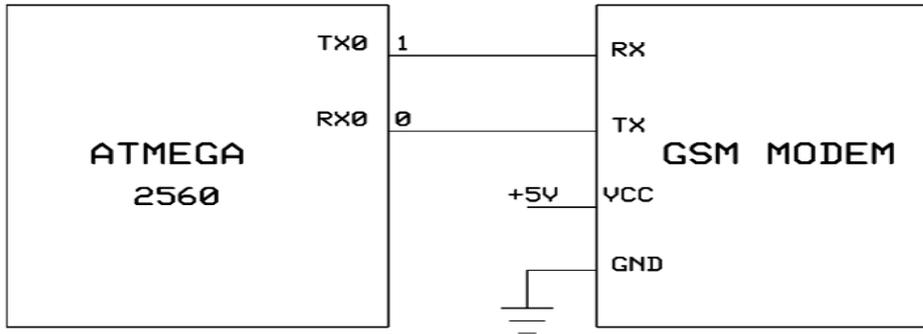


Figure 6: GSM Modem-Microcontroller Interface

5.5 INTERFACING 2X16 CHARACTER LCD WITH MICROCONTROLLER

A 2x16 LCD is attached to the device. It is used to display the latitude and longitude data so as to be sure correct data is being sent. A 2x16 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data

to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

The LCD is used in 4 pin mode. In 4-bit mode the data is sent in nibbles, first the higher nibble then the lower nibble. The four data pins of the LCD are connected to pin 4, 5, 6 and 7 of the microcontroller. The R/W pin and VSS pin are connected to ground (0V level), the register select pin (RS) and Enable pins are connected to pin 9 and of the microcontroller respectively. The VDD pin is connected to VCC supply and VEE pin is also connected to the VCC through a variable resistor.

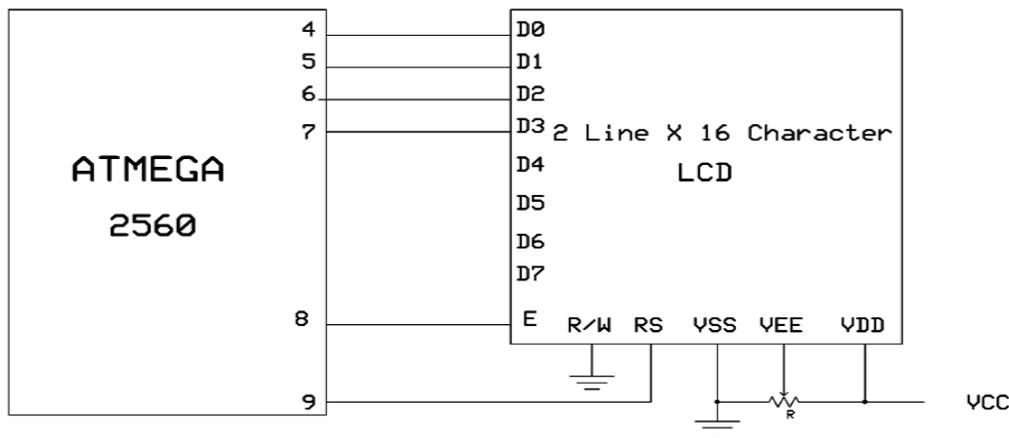


Figure 7: Keypad-Microcontroller Interface

5.6 INTERFACING 4X4 MATRIX KEYPAD- MICROCONTROLLER

A 4X4 matrix keypad is used in this design for changing the care giver's mobile number to which the location of the dementia patient will be sent. This 16-button keypad uses a combination of four rows and four columns to provide button states to the microcontroller. Underneath each key is a pushbutton, with one end connected to onerow, and the other end connected to one column. In order for the microcontroller to determine which button is

pressed, it first needs to pull each of the four columns (pins 1-4) either low or high one at a time, and then poll the states of the four rows (pins 5-8). Depending on the states of the columns, the microcontroller can tell which button is pressed.

Here, the four rows pins of the keypad are connected to pins 22, 24, 26, and 28 of the microcontroller and the four columns of the keypad are connected to pins 30, 32, 34 and 36 of the microcontroller. A +5V is connected to VCC pin of the Keypad.

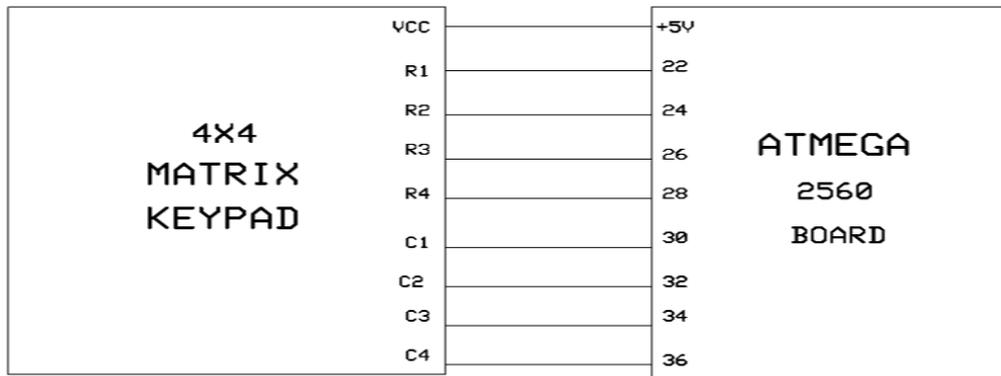


Figure 8: Keypad-Microcontroller Interface

5.7 INTERFACING EMERGENCY BUTTON AND DATA CHANGE ENABLE BUTTON WITH MICROCONTROLLER

Two push buttons are used in this design one for emergency request and the other for enabling mobile number changing function. Pushbutton is a component that connects two points in a circuit when you press it. Three

wires are connected to the Arduino board. The first goes from one leg of the pushbutton to 5 volt supply. The second goes from the corresponding leg of the pushbutton to ground. The third connects to a digital i/o pin (here pin 10 for emergency request and pin 17 for Data change function enable) which reads the button's state.

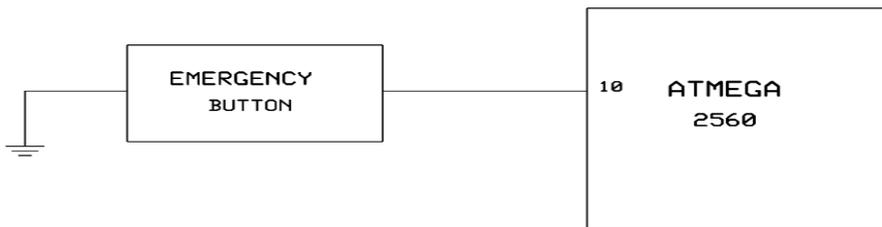


Figure 9: Emergency Button-Microcontroller Interface

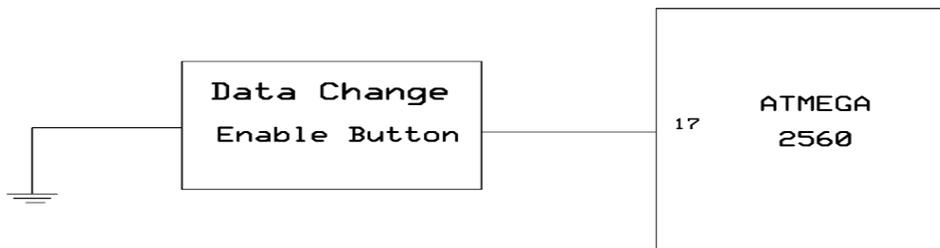


Figure 10: Data Change Enable Button-Microcontroller Interface

6. SOFTWARE DEVELOPMENT

The software program is written in C programming language using Arduino Integrated Development Environment (IDE). Arduino Software (IDE) connects to the Arduino hardware to upload programs and communicate with them. Data (co-ordinates) received by GPS from the satellites is defined in the software program. The latitude and longitude data are extracted from the received data. The mobile number of the

recipient is included in the software programming which could be change later through the keypad. The program starts when the device is switched on and stops when the device is switched off. In the interrupts service routine flow chart INT1 is activated when Data Change Enable Button is pressed. INT2 is activated when a call is received through GSM Modem while INT3 is activated when Emergency Button is pressed.

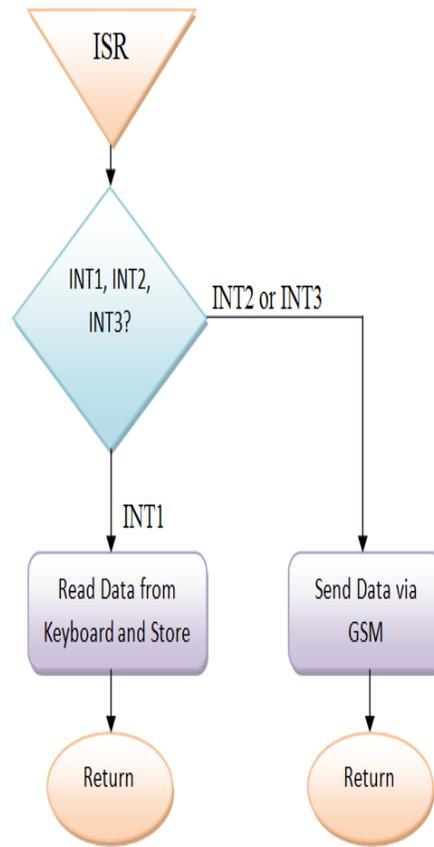
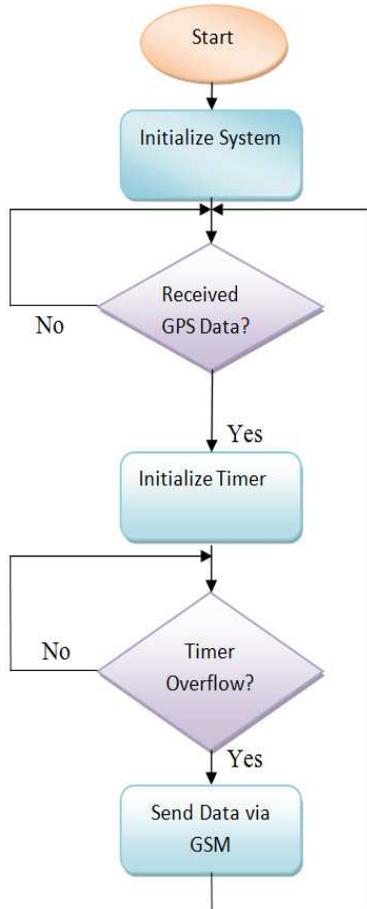


Figure 11: Main Program Flow Chart Figure 12: Interrupt Service Routing Flow Chart

6.1 SYSTEM SIMULATION

The system is simulated by using Proteus software. Since the GSM Modem and the GPS

receiver are not available on Proteus, data transmitting and receiving functions are tested in Virtual terminals.

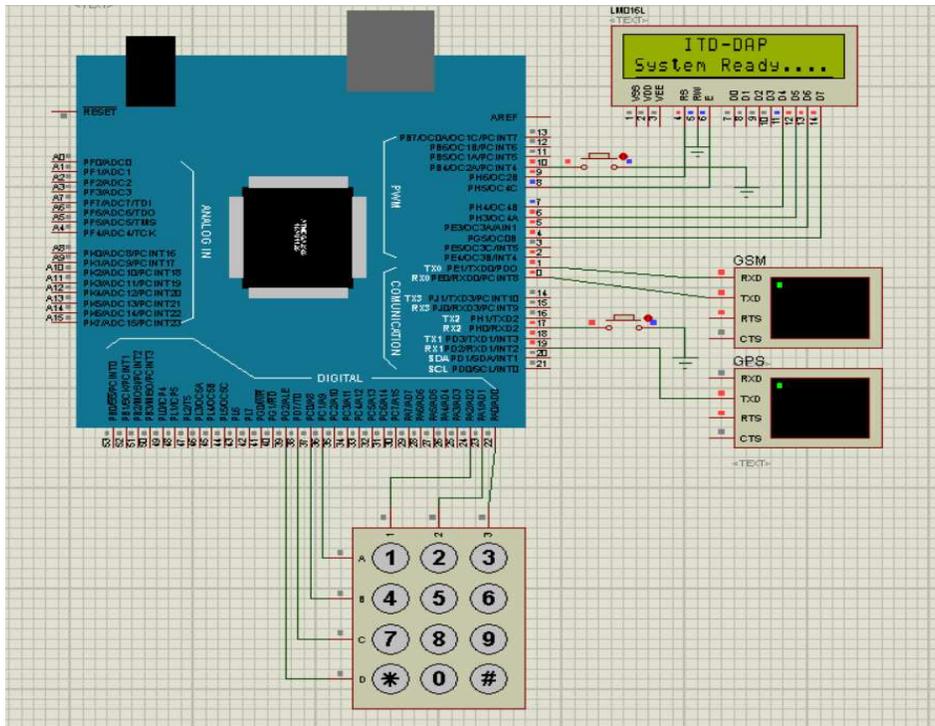


Figure 13: Intelligent Tracking Device for Dementia Affected Persons Simulation on Proteus

7. TESTING AND EVALUATION

The functionality of the overall system was tested. The system successfully reads the data from GPS receiver and display on LCD and also sends the data via GSM. Data change feature was tested by changing recipient's mobile

number. When the button is pressed “Enter Number” appeared on the LCD”. A new mobile number was added. Meanwhile, any data sent is received by the new phone number.



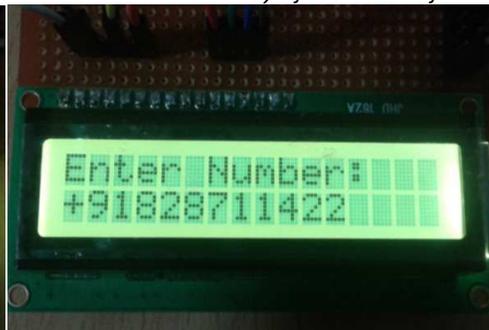
a) System Initialization



b) System Ready

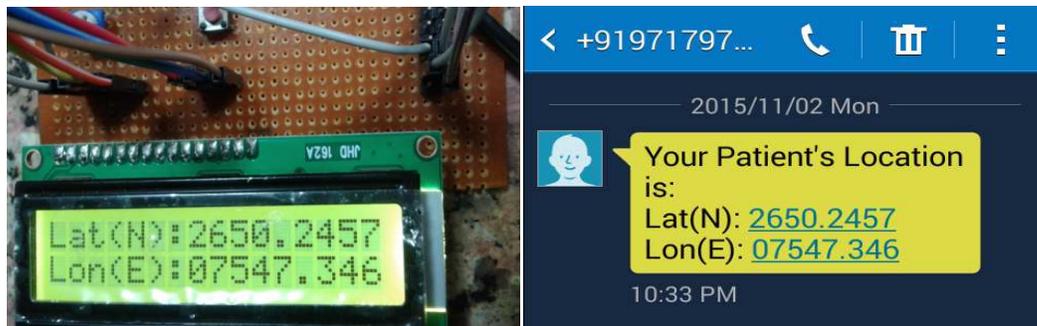


c) Change Number Feature



d) New Mobile Number

Entered



e) Result on LCD

f) Received SMS on the User's GSM mobile phone

Figure 14: Test Results of Hardware Unit

8.1 CONCLUSION

An Intelligent tracking device has been developed for dementia affected persons. The device is based on GPS and GSM technologies. GPS receiver is used to extract the location of the patient by linking itself to satellite. GSM modem is used for global range wireless communication. A microcontroller is programmed to control the overall function of the device. The device receives longitude and latitude coordinates' data from GPS receiver, display it on LCD and transmit same by SMS over GSM communication protocol. Keypad is used to enter the recipient's data. The system functionalities have been tested individually. The system successfully reads the data from GPS receiver and display it on LCD and also send the data via GSM. The efficiency of the device in sending alert messages is excellent. Delay may be experienced depending on the mobile phone company service, but otherwise the device sends alert messages immediately. The device is overall user-friendly, and it does not take long to understand the functionality of this device. Primarily the device has been

designed to help dementia affected persons to remain in contact with either family or care giver. Nevertheless, the device can also be used in search and rescue of dementia affected people who lost their way.

8.2 Future Scope

Initially it is suggested that the device be compacted and made as a pendant to be worn around the neck. This can be further miniaturized and converted to be worn like a wrist watch.

The device should not only have tracking capabilities but also be able to measure heart rate, blood pressure, and temperature of the body. Currently, blood pressure apparatuses, pulse monitors, heart rate monitors, and glucose meter are all separately available. Dementia affected persons lose track of all these devices, and they forget where they put which device. Ideally there should be just a single device that can perform tracking function plus basic health checkups allowing remote monitoring of health parameters of the dementia patients as well.

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