A Low Cost GSM and GPS Enabled Liquid Fall Detection System for Medical Applications

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***Abstract*—The most common adverse event in adults/patients is fall. The fall management has always caused a major challenge in medical systems. Fall in adults/patients can cause major health complications that can ultimately leads to health decline and increases the medical care cost. Many of latest technologies have been in use for fall management like GPS enabled Tri-axial Accelerometers (MEMS), Gyroscopes and Magnetometers etc. This paper presents human fall detection system by using a inexpensive approach of Liquid Fall Detection System (LFDS). It uses GSM architecture for information transformation through SMS. It is also GPS-Based location awareness fall detection system that facilitates immediate positional information to the caretakers. Obviously, the integration of location awareness, GSM and fall detection technologies fulfills the requirements of delivering critical information to respective persons.**

***Keywords*— Liquid Fall Detection System (LFDS), Dual Band GSM Modem, GPS Receiver, Microcontroller.**

I. INTRODUCTION

The phenomenon of fall is most surprising & challenging task for scientific community to understand & manage. Fall in elderly people is one of the most common event that adversely affects health & hence increases medical care cost. The fall management is a major challenge in medical care quality. Thanks to latest technologies that are available to manage the fall mechanism. The GSM & GPS technologies have been inherently used for fall management along with suitable high precision fall sensors like MEMS 3 & 2 axis accelerometers, gyroscopes and magnetometers etc. A variety of combinations of different technologies have been reported in the literature. A Bluetooth based MEMS with 3-axis accelerometer is used for short distance communication for multi category human motion recognition [1]. The use of Zigbee (for little larger distance) with different MEMS for physical activity monitoring have been reported [2,3,4]. Researchers have suggested the use of body area sensor network for body posture recognition [5]. The RFID reader is being used as iGrabber with Bluetooth for fall detection system [6]. The indoor activity monitoring of adults with MEMS & Zigbee wireless communication is well suited for this particular application [7]. Monitoring & controlling of physiological parameters by using SMS techniques with the aid of GSM & GPS network proved as realistic one [8-10]. Sometime only location awareness of the patient/people becomes a vital tool using GPS network [11]. Use of such various technologies does not restricts to only medical care quality improvement but also other applications like plane optical tracking & measurement, train arrival detection system and some multiple message display systems [12-14]. But the fascinating uses of these technologies are really well suited for blind people whose life activity is quite different from normal people [15].

The aim of the proposed work is to design & implement a very low cost, novel approach for fall sensing by using liquid. This paper deals with design of such a Liquid Fall Detection System (LFDS) that uses GSM & GPS network to transfer the vital information like fall & location information. The design of hardware and software for a compact, reliable and low cost system to achieve remote monitoring of fall is studied. In this system, minimum fall angle is calculated & calibrated around the plane of ground & perpendicular to it. In the event of fall, the system displays messages on LCD display and gives buzzer to alert the people around and to seek help from them, apart from sending a SMS to caretaker with status of the patient.

II. THE SYSTEM OUTLINE

In this paper we have proposed a low cost GSM & GPS enabled Liquid Fall Detection System. The system has two parts, one is the system unit & the other is mobile unit or a cell phone. It makes use of GSM architecture/network & its facility for mobile communication to transmit the status of fall of the person to an authorized person's cell phone. In this proposed system, both system unit & mobile unit (a cell phone) can acts as transmitter & receiver, because it is a bi-directional communication system. The system unit, which is an embedded microcontroller based, collects the data from the Liquid Fall Detection System and finds the status 0 or 1, it sends an SMS to the caretaker's cell phone.

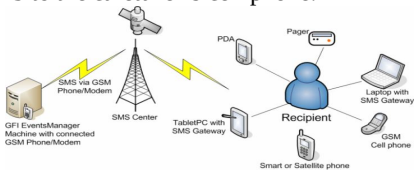

Fig.1. The system outline

The system uses GPS technology for location awareness by taking Longitudinal & Latitudinal values of the geographical location of the GPS receiver and sends them in the form of SMS. The system responds to SMS messages sent by the doctor or caretaker, verifies the authenticity and then sends a

reply to SMS. With this response i.e. SMS sent by the system, the doctor or the caretaker can know the fall status of the person or patient.

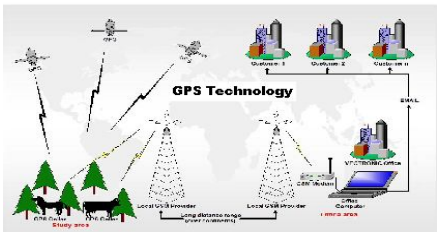

Fig.2. The GPS technology

III. HARDWARE FEATURES

Fig.3 shows the block diagram of the proposed system. The hardware has two sections i.e. system unit and remote unit (Cell Phone) (which is not shown in fig). The hardware feature of this proposed system includes simple general components of a standard embedded system and is built on 51-architecture. The details of few hardware components are;

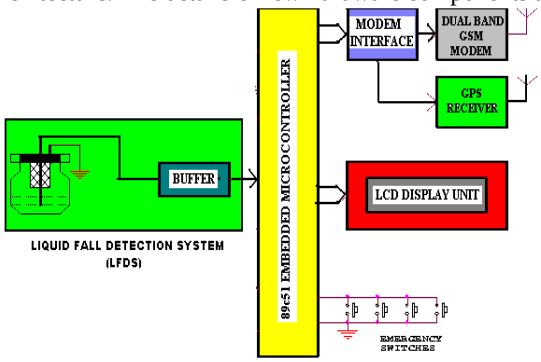

Fig.3. Block diagram of System Unit

1. Embedded Microcontroller.
2. Dual Band GSM Modem.
3. GPS Receiver
4. Liquid Fall Detection System (LFDS)
5. LCD Display unit.
6. Emergency Switches
7. Power Supply.

Embedded microcontroller:-The microcontroller chosen for this work is Atmel's 89C52 and it does all controlling activities of the system by executing a program stored into its flash program memory. It is an 8-bit microcontroller with 8-k bytes of internal flash program memory, 256-byte data memory and 4-I/O ports. It also consists of a full duplex serial UART and internal timer/counter. It is an ideal choice for compact embedded system design for such applications. The dedicated software has been designed in 8052 assembly language using Keil IDE software suit.

Dual band GSM modem: - It is a wireless MODEM and can send and receive data through the GSM network. It requires a SIM card and connectivity to the GSM network. It consists of built in TCP/IP stack. The GSM MODEM communicates with the embedded microcontroller system with the help of AT commands. It works on two frequencies i.e. 900 MHz and 1800 MHz for up-linking and down-linking. This MODEM is designed to work on RS232 standard, hence, while connecting to microcontroller, a RS232 to TTL level converter is required.

GPS receiver: - GPS (Global Positioning System) is a network of satellites that constantly transmit coded information, which makes it possible to accurately identify locations on earth by measuring distance from the satellites. Generally, most GPS receivers support the NMEA (National Marine Electronics Association) GPS Receiver is available as interface modules from various manufacturers. Most GPS are capable of sending information through a simple serial link. The GPS Receiver proposed to be used in this system will receive the coordinates needed from the GPS satellites. It will send the information to the microcontroller. Because of its small size and low power consumption, it can be embedded into many portable devices. It has the capability to refresh its data once every second and therefore will be continuously updating the coordinate's values for the microcontroller as the person changes location.

Power supply unit: - Since this instrument has to be carried by the patient while moving. Hence it is essential that the entire patient's unit has to be designed to work on batteries. It consists of rechargeable batteries, filter capacitors and voltage regulators. The batteries can be charged by a regular charger.

Subscriber Identity Module: - The best key feature of GSM is the Subscriber Identity Module (SIM), usually called as a SIM card. The SIM is a removable smart card containing the user's subscription information and phonebook.

Short Message Service (SMS):- Short Message Service (SMS) is famous among mobile phone users as a low cost and convenient method of communicating. As the use of SMS technology is a cheap, convenient and flexible way of conveying data, researchers are using this technology in many different areas that were not provided by service providers. One of such areas that the SMS technology could be used a cost effective and more flexible way of remote monitoring and controlling.

Liquid Fall Detection System: - The tilt sensor is used to sense fall of the patient. To detect the fall angle an apparatus is designed with a bi axial mechanical accelerometer in our laboratory & it is discussed as below. It is attached to the patient's body and is kept in upright position. It consists of a glass bottle filled with a conductive fluid and two electrodes, an inner electrode and the outer electrode. The outer electrode is in the form of a wire mesh and the inner electrode is a straight wire. The inner electrode is longer than outer electrode and is always in contact with the fluid. The fluid level in the bottle is so adjusted that it touches both electrodes only when it is considerably tilted. The following parameters have obtained after the calibration to detect the fall. Bottle length = 5.7cm, Outer diameter = 3.2cm, Total volume of the conductive liquid = 25ml & volume of the liquid at the sensor level = 14ml. The fall is categorized in two types i.e. REAL FALL & VIRTUAL FALL. According to human body

posture, the real fall is one when the body touches horizontally to the plane of the ground. The virtual fall is simple bending of the body.

Fig.4. Shows bi-axial mechanical inclinometer for fall angle measurement & right image shows 24 deg fall angle.

The apparatus discussed in the previous section is used for the calculation of fall angle. It is calibrated and used to calculate the fall angle with fall status FS=0 or FS=1 is as shown in the below table. The table 1 shows the sensor status for different angles from 0 deg to 45 deg. Note the fall angle 24 deg for which the sensor status is 1 i.e., the sensor indentified the fall angle & this fall angle is same to all directions around the circular plane as shown in fig 4.

TABLE1

FALL SENSOR STATUS FOR DIFFERENT ANGLES

Angle of Tilt	Fall Sensor Status
0 deg	NO (FS=0)
5 deg	NO (FS=0)
10 deg	NO (FS=0)
15 deg	NO (FS=0)
20 deg	NO (FS=0)
24 deg	YES (FS=1)
30 deg	YES (FS=1)
35 deg	YES (FS=1)
40 deg	YES (FS=1)
45 deg	YES (FS=1)

The geometrical representation of this is as shown in fig 5.

Whenever the patient fall occurs, the bottle is tilted abnormally, it sends a signal to microcontroller, this microcontroller in turn sends SMS with FS=0 or FS=1 with the help of GSM network.

The GPS sends geographical position of the device on the earth with longitude & latitude, so that location awareness can be identified properly.

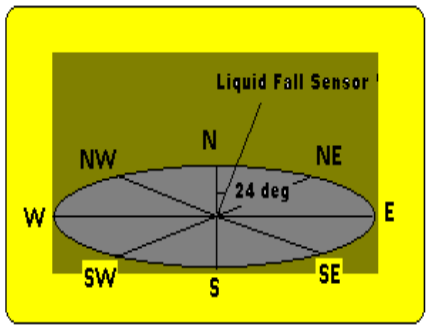

Fig.5. Graphical representation of fall angle

V. SOFTWARE IMPLEMENTATION

This system is a dedicated embedded system, software has written & stored in the memory of the system. The system comes to ON condition from RESET position then the program is executed and as per fall sensor status it displays the message locally on the LCD and also sends SMS to caretakers.

VI. EXPERIMENTAL RESULTS & DISCUSSIONS

The experiment is conducted in the laboratory, the main objective was to find the minimum fall angle to which the sensor responds. Hence, a new approach of liquid fall detection system was used. It consists of a glass bottle filled with a conductive fluid and two electrodes, an inner electrode and the outer electrode. The outer electrode is in the form of a wire mesh and the inner electrode is a straight wire. The inner electrode is longer than outer electrode and is always in contact with the fluid. The fluid level in the bottle is so adjusted that it touches both electrodes only when it is considerably tilted and the fall angle is measured on specially laboratory designed bi-axial mechanical inclinometer. The results are shown in table 1. This system has to show its feasibility with GSM connectivity for fall monitoring and intimation of medical emergencies along with location identification ability. It was aimed to allow the fall status of a person to be automatically identified from any position without the limitation of distance and make use of well established GSM mobile technology for communication and GPS technology for location identification & thus to extend the range to unlimited value. The person himself can ask for the help by pressing a button or a micro-switch attached to the instrument whenever fall occurs. If there is nobody to help the person, the microcontroller obtains the geographical locations from GPS receiver to calculate the latitude and longitude of the place and prepares a concise SMS and sends the information through the GSM modem to the mobile phone of the doctor/care taker. It helps such people to get the critical help in time. Thus it can assist the handicapped/elderly people and also serves as a life saving instrument for critically ill patients. The photo graph of the whole experimental setup is shown in fig.6.

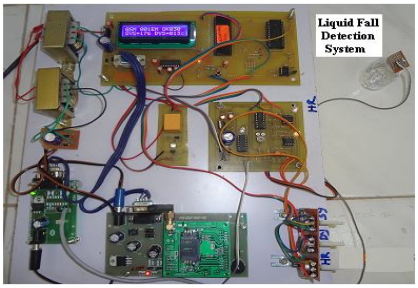

Fig.6. Photograph of the experimental setup

From the above discussions it is clear that the system is automatic, wireless, portable and does the communication of fall status of a person along with GPS position for location identification to the caretaker's/doctor's cell phone as shown in fig.7

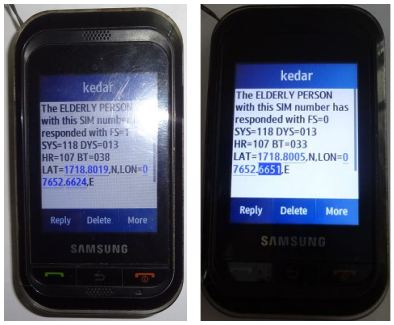

Fig.7. Photograph of a Mobile phone with SMS sent by the Wearable unit

The details of this SMS are as follows:

- FS=0 (Fall Sensor inactive)
- FS=1 (Fall Sensor active)

The GPS locations are:

- LAT=1717.9893.N (Latitude North)
- LON=07649.1224.E (Longitude East)

VI. Conclusion

This paper presents design & development of a very low cost GSM/GPS enabled liquid fall detection system for medical application. Here the implementation of the system is made to sense, send, display and store the physical activity such as fall of adults/patients. The system is designed and developed successfully in the laboratory. As compared to different fall detection systems like accelerometers (MEMS), gyroscopes, magnetometers etc this liquid based fall detection system cost is very much negligible. As for as error factor is concerned it is +/- 1 deg when compared to a large fall angle i.e. 24 deg. The developed system is simple, low cost and potable. The final goal of the work was to reduce the cost of fall detection system, hospitalization & assistance and to increase patient's quality of life. This system has functioned reliably and can be used by people suffering from variety of medical ailments & thus to improve medical care quality of adult people.

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