Smart Health Monitoring Vest with Bullet Detection for Soldiers

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Abstract— In any country, soldiers are always the frontline defense. Nevertheless, they always give their best by defending the nation by risking their lives. It is always the case that a soldier is injured on a battlefield barbarously. The things that protect the soldier's life are only a bulletproof jacket and second-generation devices. What the Indian Army has are limited second-generation devices, which at times are more of a hindrance than an asset. The bulletproof jackets used by our Indian soldiers is made up of a material known as Kevlar which does not provide 100% security in proving that the bullet cannot pass through it. Hence, it becomes important to think about securing the lives of our soldiers and develop means of providing 100% security to their lives. The goal of our project is to develop means to provide security to the soldiers' lives by making a bullet detection jacket along with the location of the soldiers. The bullet detection system, which is implemented in a vest, will find the position of the bullet faster while seeking medical help in emergency. The vest was formulated to rectify those problems, enhance the soldier's condition and eventually decrease the number of the death of the soldiers.

Index Terms— Base station, Bullet detection system, Health monitoring parameters, Vest.

1 INTRODUCTION

INDIA stands in the fourth rank of having the most powerful armed forces in the world. The weaponries and devices used by the Indian Army is very modern. However, when it comes to the clothing with respect to the shielding and health monitoring, it does not prove to be protective enough. At present, our Indian soldiers use bulletproof jackets, helmets for shielding. The material used in making the bulletproof jackets is called Kevlar. Though Kevlar is thought to be bulletproof, it does not assure 100% protection. Because of this reason, our soldiers are supposed to compromise about the security of their lives. Currently, the Ministry of Defense spends around Rs.1.5 Lakhs on a single bulletproof jacket, imported from USA that the soldiers from military forces use. Therefore, the Ministry of Defense spends up to Rs. 20,000 Crore annually. However, the drawback of this jacket is that it weighs around 15-16 kilograms. Due to this reason, these jackets are more of a hindrance than an asset. In addition, the soldiers are facing a lot of problems with respect to the food, non-cooperative terrains, unfavorable climatic conditions, sub-zero temperature regions as well as clothing. The army still wears the clothing that was designed as normal high altitude clothing when they have to fight against terrorists in jungles and mountains, which are very bulky and noisy. Unfortunately, they cannot get rid of it, as they will have to compromise with the warmth in the subzero temperature regions. All these factors are very serious because it is a matter of life and death. This praiseworthy life of a soldier is unpredictable. The reasons are numerous, but can still be decreased. Though the soldiers are trained to overcome all the hurdles in the battlefield, their condition is more pitiful than a civilian can imagine. No insurance company can guarantee the life of a soldier.

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The United States being the most powerful nation in the world has already implemented innovative technologies in the army after having done a lot of research on the body armour suits that would protect, enhance and sustain the soldiers' lives. Similarly, we Indians can stand by our soldiers while they stand by us for our protection.

The problems of the soldiers mentioned above can be overcome by providing security by monitoring the soldiers' health parameters by developing a vest, which has various health monitoring parameters and a bullet detection system designed in it. Our main objective is to detect the position of the bullet shot in the armour suit, provide health security and the soldiers' location identification and report all the data to the base station simultaneously. In this way, the soldiers are constantly monitored by the base station. This will help to provide security and protect the soldiers' lives if they can be easily tracked and monitored. Generally, the Army camp sets out rescue teams in search of the soldiers who go missing. This process takes nearly a period of more than six months. Therefore, the GPS as well as the accelerometer in the vest can help the rescue team to locate the soldier's position much faster and can save them as early as possible.

2 LITERATURE SURVEY

Sujith N S. et al. [1] studied various materials used in bullet proof jackets and identified the best one based on directional deformation, total deformation, shear stresses and principal stresses when it is subjected to bullet impact. He used composite material because of its high specific strength and specific stiffness, good corrosion resistance and good fatigue resistance. Bogdan Muset et al. [2] describe a system to measure the distance travelled by a person inside a building, which is alternative to GPS. An algorithm was developed that measures the distance traveled by counting the number of steps. The advantages in using this method are low cost and portability sensor circuit. M.V.N.R. Pavan Kumar et al. [3] has

written the paper which has the idea of tracking the soldier and navigation between soldier to soldier by knowing their speed, distance, height as well as their health status during the war, which enables the army personnel to plan the war strategies. He proposed wristwatch to display position, direction, surrounding temperature and it acts as an altimeter. R. Archana et al. [4] described a system, which can monitor the health parameters, location and real-time video transmission, wound and bomb detection to the base station from soldier unit. The soldier unit consists of pulse rate sensor to sense the heartbeat, bomb sensor detects the presence of explosive chemicals around the soldier, vibration sensor, made up of piezoelectric sensors, detects any wounds caused by gun shot or explosion, camera, to transmit the real time video of the soldier's mission through RF transmitter, temperature sensor to sense the temperature of the surroundings. GSM is used for the communication and transmitting the health and other parameters of the soldiers to the base station. GPS gives the position of soldier to the base station. Rosarium Pila et al. [5] described an innovative and robust way to count human steps using accelerometer and proximity sensor. The proximity compensation mechanism along with motion detection by accelerometer ensures to prevent false step detection. When proper motion is recognized by accelerometer, the time of flight sensor, on proximity to the ground will detect a real footstep. The idea of this paper is an original one, though various individual health monitoring ideas for the soldiers has already been proposed. Hence, all the ideas of these papers were put together along with an efficient bullet detection system to build one efficient vest which tries to avoid the major problems faced by the soldiers.

3 PROPOSED METHODOLOGY

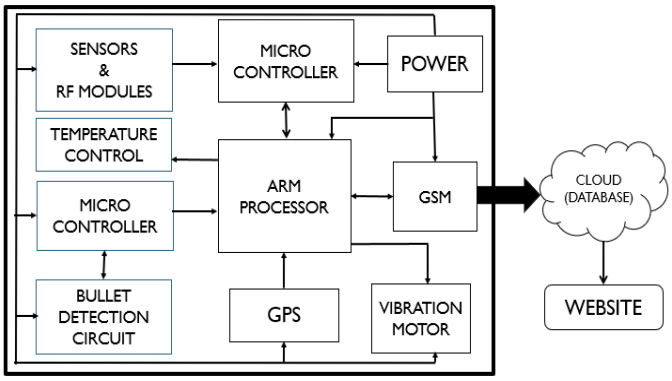


Fig.1. Functional block diagram

The proposed system is on a vest, which consists of various health monitoring parameters and a bullet detection system. The health monitoring parameters include sensors such as temperature sensors (for both body and environmental temperature measurement), pulse rate, motion sensor, and accelerometer. The bullet detection system is devised from the method of matrix keypad. Fig.1. shows the functional block diagram of the methodology.

All the sensor data along with the bullet detection data will be processed and transmitted through GSM (Global System for Mobiles), where it will store all the values in the databases at the server side. Since the server side has high-speed processors, all the processing will be done at the server side only. Due to this, the limitations of the battery power consumed at the client side will be reduced.

An efficient algorithm is developed and threshold values are set based on the requirements. With the help of a MCU, a GSM/GPRS module and a Server, the soldier is efficiently monitored.

4 IMPLEMENTATION

4.1 Hardware Implementation

4.1.1 Sensors

The sensors used in this project along with their goals are listed in the table. The sensor is to be placed with precision and care. Whenever the soldier is in the battlefield, the sensors start sensing his health parameters. The health monitoring sensors in the vest include pulse sensor, used to measure the heart rate of the soldier. The threshold values is as low as 60bpm and as high as 120bpm. The heartrate of the soldier is updated to the base station if it drops or exceeds the minimum or maximum threshold value respectively. There are two temperature sensors used, one for body temperature and another for environmental temperature and humidity calculation. The threshold for the environmental temperature is set for 10 degree Celsius. If the temperature goes below this threshold, heating process inside the vest is activated to provide warmth.

The soldier is tracked via GPS (Global Positioning System) which requires satellite, but accelerometer is used as an alternative to calculate the number of footsteps to determine the movement of the soldier. Whenever, the soldier is at rest, the motion sensor detects the intruder and causes the vibration motor to alert him.

TABLE 1
DETAILS OF THE SENSORS USED

Sensor/ component	Purpose
Pulse sensor	Heart rate calculation.
Waterproof Temperature sensor	Body temperature measurement.
Temperature and Humidity sensor	Environmental temperature and humidity measurement.
Accelerometer	Calculation of number of steps walked.
PIR sensor	Intruder alert.

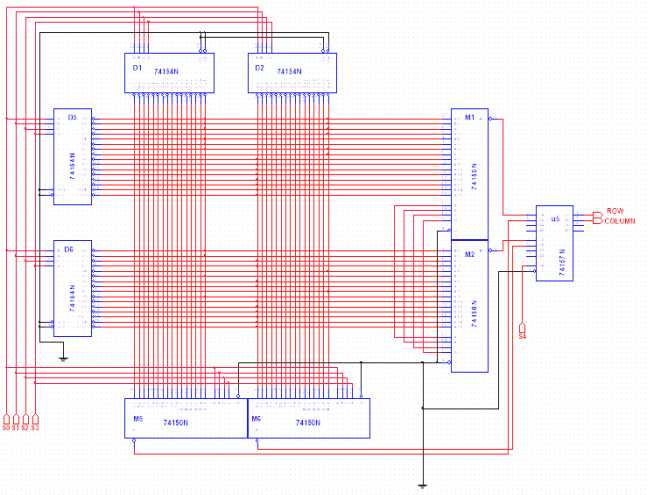
4.1.2 Micro controller Unit

We use lilypad ATmega328V and Adafruit Feather nRF52832 Bluefruit in our Micro Controller Unit (MCU). The lilypad is powered by a supply voltage of 2.7-5.5V and the Adafruit is given a supply voltage of 1.7-3.3V. One of the lilypad is programmed for bullet detection and the other for all the sensors. The Sensors are wired and connected to the MCU through its input ports. The Micro Controller Unit performs correspond-

ing action for received sensor value. The Micro Controller Unit is interfaced with GSM to transmit the data to the base station.

CLK. PULSE	DEMUX I/P		SELECT LINES					OUTPUT		
	G_2^1	G_1^1	S_0	S_1	S_2	S_3	S_4	DEMUX	MUX NO SHOT	MUX SHOT
1	0	0	0	0	0	0	0	1	1	0
2	0	0	0	0	0	0	1	1	1	0
3	0	0	0	0	0	1	0	1	1	0
4	0	0	0	0	0	1	1	1	1	0
5	0	0	0	0	1	0	0	1	1	0
6	0	0	0	0	1	0	1	1	1	0
7	0	0	0	0	1	1	0	1	1	0
8	0	0	0	0	1	1	1	1	1	0
9	0	0	0	1	0	0	0	1	1	0
10	0	0	0	1	0	0	1	1	1	0
11	0	0	0	1	0	1	0	1	1	0
12	0	0	0	1	0	1	1	1	1	0
13	0	0	0	1	1	0	0	1	1	0
14	0	0	0	1	1	0	1	1	1	0
15	0	0	0	1	1	1	0	1	1	0
16	0	0	0	1	1	1	1	1	1	0
17	0	0	1	0	0	0	0	1	1	0
18	0	0	1	0	0	0	1	1	1	0
19	0	0	1	0	0	1	0	1	1	0
20	0	0	1	0	0	1	1	1	1	0
21	0	0	1	0	1	0	0	1	1	0
22	0	0	1	0	1	0	1	1	1	0
23	0	0	1	0	1	1	0	1	1	0
24	0	0	1	0	1	1	1	1	1	0
25	0	0	1	1	0	0	0	1	1	0
26	0	0	1	1	0	0	1	1	1	0
27	0	0	1	1	0	1	0	1	1	0
28	0	0	1	1	0	1	1	1	1	0
29	0	0	1	1	1	0	0	1	1	0
30	0	0	1	1	1	0	1	1	1	0
31	0	0	1	1	1	1	0	1	1	0
32	0	0	1	1	1	1	1	1	1	0

The GPS module is interfaced with Adafruit to locate the soldier's position based on latitude and longitude. If the GSM fails, RF modules are used as an alternative for communication. All the devices are driven by a high specific energy Lithium-ion polymer battery.



4.1.3 Bullet Detection System

The proposed system is devised from the method of matrix keypad. As the keypad matrix is structured like a mesh, the bullet detection system is also designed like a mesh on a vest.

Fig.2. Bullet detection system block diagram

Fig.2. shows the block diagram of the bullet detection technology. The matrix method of bullet detection system is a circuit made up of a DEMUX-MUX combination as shown in the Fig.3.

Fig.3. Circuit diagram of bullet detection system

The vest acts as an asset as it comprises of the Bullet Detection system. The Bullet Detection tells the exact location of the bullets in the soldier's armor to the base station immediately.

TABLE 2
32X32 TRUTH TABLE

The working principle is similar to the matrix keypad where the corresponding value at the row and column can be determined by knowing the change in the switch positions.

The mesh is created by extending single-strand wires from the DEMUX output to the input of the MUX. The circuit can be designed by using a set of demultiplexers (IC74HC4514) and multiplexers (IC74150N) each for rows and columns respectively. These two IC's are 1:16 demultiplexer and 16:1 multiplexer. Hence, this makes up a 32x32 bullet detection mesh. The horizontal and vertical wires represent the rows and columns respectively. The select lines of all the demux and mux have to be shorted. From the controller a low input given to the demux ICs, which will produce a low output. The output from the demux is given as an input to the mux ICs. From the experiments conducted with the help of the IC Trainer Kit, it is observed that the mux will produce a high output if there is connectivity and low output if the connection has been broken. This can be verified with the truth table as in TABLE II. The implementation of this system on a vest makes it a wearable device that can detect the position of the bullet in the armor by the base station are constantly monitoring the soldiers.

4.1.4 Communication

GSM/GPRS module is used for communication between a processor and base station. Global Packet Radio Service (GPRS) enables higher data transmission rate by sending data in packets in a GSM network. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. We are using GSM module, SIM 800I. It has features such as SMS Control, data transfer, remote control and logging. SIM 800I works on the power supply of 3.4-4.4V and has a maximum upload and download speed of 85.6 kbps.

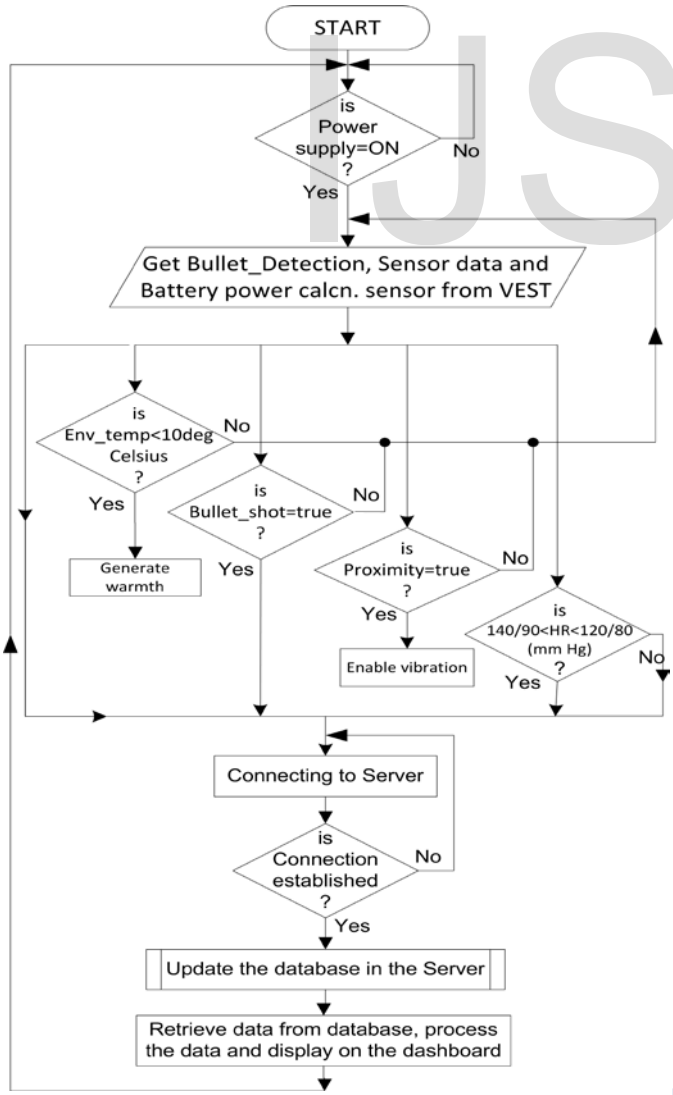
4.2 Software Implementation

4.2.1 Client side Programming

The Micro Controller Unit that uses Adafruit and Lilypad is programmed by using Embedded C programing. Arduino IDE is used for programing the Micro Controller Unit, which

is simple and more efficient open-source software, which enables users to edit and burn the program to the lilypad and Adafruit. There are different open source libraries available which makes the coding a lot easier. The Micro Controller Unit is programmed in such a way that it gets the outputs of the sensors from its analog and digital ports. These values are taken as variables in the code and substituted in the code to get the desired output from Micro Controller Unit. The MCU is programmed in such a way that it does some specific action for a specific value obtained from each of the sensors, as written in the code. The threshold values like minimum heart rate and environmental temperature are stored in the Micro Controller Unit and if heart rate and the temperature drop below that, it will update the base station for emergency, similarly for the bullet shot. The vibration motor is activated if the intruder comes within the proximity range. Therefore, Micro Controller Unit knows what action must be performed for the particular value obtained from different sensor. A GSM module and a GPS module is interfaced with the MCU unit to transfer the data to the database or base station and to locate the soldier's position respectively.

4.2.2 Server side Programming



The sensor data obtained from the soldier's vest is pushed to the server through the http (hypertext transfer protocol) post requests. The entire computing takes place in the server side rather than the client side as the server computer has high-speed RAM capacity. MySQL database is running on the server end which stores the sensed data i.e. pulse rate, body temperature, environmental temperature and humidity, proximity, accelerometer values, the rows and columns of the bullet shot, which is used for further analysis. The backend is designed using PHP (Hyper Text Preprocessor) and JS (JavaScript) and the front end using CSS (Cascading Style Sheets) and HTML (Hyper Text Markup Language).

5 Basic Algorithm

Fig.4. Flowchart explaining the basic operation of the Service Sense technology for single sensor.

The algorithm is as follows which is explained through flowchart in Fig. 4. When the soldier enters the Warfield, the vest starts sensing the health parameters. It also starts sensing the bullet shots in the upper half of his body, as well as the values for heartrate. After all the parameters are compared, they are checked with the threshold values set. Here, the threshold for the environmental temperature is set for 10 degree Celsius. If the temperature of the region where the soldier is located drops below it, the vest activates the heating mechanism to provide warmth. The same goes with the pulse rate sensor. The proximity sensor detects whether an enemy is close to the soldier, if it is affirmative, then the vibrator motor enables vibration to alert any sub-conscious soldier. The vest is constantly checked for any bullet shots. All these parameters are constantly monitored and the checked data along with the other input data such as position, battery power are updated to the databases in the server. The base station can retrieve the data from the databases and display it on the dashboard. The front end of the webpage is designed in such a way that all the parameters are displayed that can be easily analyzed and recorded. This algorithm works as an infinite loop to constantly monitor the soldiers.

6 Benefits

- Soldier's location can be easily tracked with the help of GSM module.
- Monitoring heartrate for prior medical help.
- Measuring the body temperature, environmental temperature and humidity to generate warmth for critical conditions.
- Calculation of number of footsteps as an alternative to track the soldiers.
- Alerts the sub-conscious soldier by activating the vibration motor when an enemy is closer.
- Detection of the bullet shot in the soldier's upper half of the body for faster medical help.
- Lightweight and flexible.

- Feasible for the base station to monitor each soldier because of the clear design of the webpage.
- Reduces the major problems faced by the soldiers to the large extent.

7 Results

A prototype of the project has been developed and tested which works according to the designed algorithm with satisfactory results. The sensors work efficiently as coded and provide accurate outputs. The bullet detection system is a 32x32 mesh for a prototype but the number of rows and columns can be increased for more accurate determination of the bullet shot. The webserver for the prototype has been designed that has all the databases of each soldier measuring all the parameters as shown in the Fig.5.

Fig.5. Screenshot of the database

The base station can effectively monitor and track each soldier as the front end of the webpage is designed such a way so that it makes everything clear and the results are shown in the Fig.6.

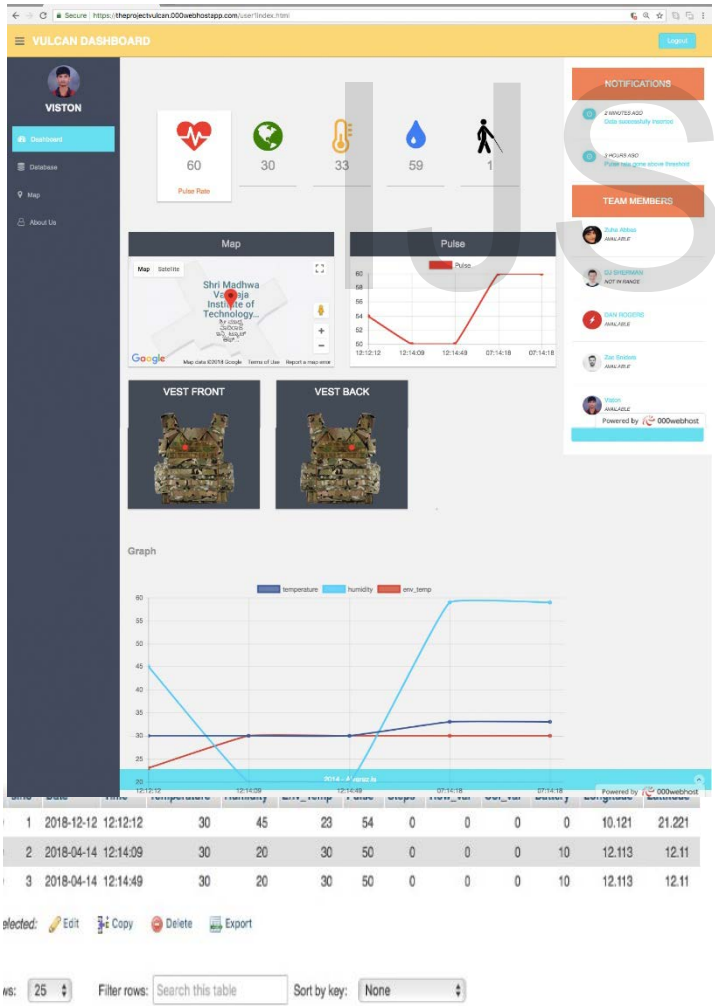


Fig.6. Screenshot of the webpage

From the survey, we came to know the drawbacks of the bulletproof jackets that our soldiers use and its cost effectiveness. As this is a unique technology with less expense than the earlier ones, this can provide best efforts to solve the major problems faced by our soldiers.

8 Conclusion

The smart vest provides security and safety for the soldiers. GPS and the RF modules track the position of the soldiers anywhere on the globe and the health monitoring system monitors soldier's vital health parameters. Soldiers can have a continuous communication with the base station. The clothing will remain lighter and durable. Body armor suits of the future for the military consist of lightweight materials, having integrated sensors and wearable devices that are meant to resist enemy attacks. This project, if implemented, would help the soldier to survive intense battle and may help to save the lives of wounded soldiers. Hence, all these developments may eventually inspire many to join the Indian Army.

Acknowledgment

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