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Research Article

Smart Haptics for Textile Applications

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A B S T R A C T

The number of terrorist attacks is increasing day by day. Most of the attacks are unexpected and thus there needs to be a system that can assist Indian soldiers in such situations. This project focuses on the development of haptic jackets which can form a medium to assist soldiers in case of such situations. The jacket is equipped with a number of smart systems which can assist the soldier on the war field. This includes monitoring the different parameters of the soldier including pulse, oxygen, heart rate, damage taken, notifying the same to the army base using the Internet of Things approach. The developed jackets also consist of smart haptic feedback systems which can alert the soldier in case of unexpected attacks and thus prevent loss of soldiers' life due to unexpected attacks. The Army base software is also developed as a part of this project where the details of all the soldiers present in the troop as well as their conditions can be monitored directly using the Web Portal provided to the Army base. The project also proposes tap to help feature where the soldier in danger can just tap on the jacket in a particular pattern and receive immediate help from the army base camp using the GPS coordinates of the soldier received on the Web Portal. The Jacket is further made failproof using a Wide array of sensors that will detect the emergency conditions such as bomb explosions, hazardous gas concentrations, etc, notify the soldier using haptic feedback as well as base camp so that immediate action can be taken. Further Soldier fall detection is also implemented using MEMS accelerometers which can help the base camp to know the soldiers falling unconscious during war. The jackets are self-powered and take the requisite energy for powering the jackets using Solar panels mounted on the jacket itself making it a completely independent system to assist soldiers in the war field using IOT. The Camera is mounted on the jackets which captures continuous video feed from the jackets and sends it to the army base camp which can be visualized remotely using IOT.

Keywords: Haptics, Sensor, Army, Jacket, Monitoring, Sensing, IOT, Development

Introduction

Soldier security has become a major issue as there is a steep increase in number of unexpected attacks on soldiers. The troops of soldiers on a mission have to face unexpected attacks everyday from enemy forces as well as militants. Majority of the attacks are from the behind or when the soldier troops are completely unaware. This results in loss of number of lives of Indian Soldiers. The Army's most valuable asset and the foundation for maintaining national peace are its soldiers. They are always in charge of accepting and maintaining the duty during all types of severe weather. While protecting the nation, they could experience difficulties in extremely cold or hot weather.[1]

The army base camp provides support to the Soldiers via radio link, however there is no such system for immediate back up in case of emergency attacks.[4] The soldiers have to face heavy firing and responding to the base camp in case of such attacks becomes difficult as well as somewhat impossible.[6] If the soldier carrying the communication channel is injured or eliminated by the enemy forces, the entire communication link of other soldiers also gets broken. Thus this is an serious issue and needs to have an effective solution.

Another existing major problem is the attacks faced by soldiers from behind during operations such as spying or surveillance.[2] Surveillance in enemy-captured areas is difficult and soldiers need to be split up individually to monitor the entire area and infiltrate it. In such situations there are more chances of attack from behind.[7] The soldier cannot simultaneously concentrate on front as well as back. Thus this puts a call for danger situation where soldiers life is at stake due to lack of improper security system.[3]

The another major problem associated is the lack of location tracing system.[5] Even if the communication link is broken or existing it is difficult to trace and location of individual soldiers and trace their real time location. Thus this calls for development of system which can handle all the above problems and secure soldiers lives. Further the project proposes the incorporation of such system in soldiers jacket. [8] Which can be used as wearable so that soldiers do not need to carry the development equipment separately.[4]

This project proposes the concept of smart haptic jackets using IOT protocol for Indian soldiers. The proposed system can assist Indian soldiers on mission using haptic feedback systems as well as provide all the details regarding Soldiers to army base camp using IOT protocol.[3] The proposed solution also consists of Immediate soldier help system using Geo-fencing system so that nearest soldiers are immediately notified regarding the emergency conditions as well the base camp if immediately notified regarding the real time GPS location of the soldier.[10] The system also consists of a camera mounted on the jackets which can take the video feed and send it to the army base panel developed which will help the base camp to visualize the video feed transmitted by the soldier.[9]

Research

The Smart Haptics For Textile Applications will be used to assist soldiers in battle zones or war area and prevent from attack of enemy soldiers. The idea will underpin how the smart haptics function. The

jacket has sensed the attacks and gives the sensation to soldiers by utilizing haptics sensors for the soldier's safety. The jacket is equipped with an ultrasonic sensor that can measure the distance to an object by using sound waves. The GPS sensor's latitude and longitude can be used to find the location of a soldier. The vibration sensors give sensations to soldiers, the gas sensor detects the hazardous gases present in the war field.

Working Methodology

This project proposes to solve all the problems faced by soldiers by providing them with smart haptic jacket. The Figure Below shows the illustration of the entire project concept.

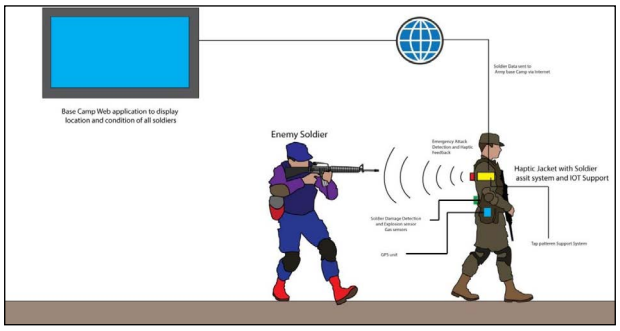

Figure 1

Block Diagram

The figure above shows the block diagram of the project. As shown in the block diagram the system consists of haptic jackets for smart soldier rescue and assist. The developed project consists of haptic jackets with different sensors equipped onto the jacket. As shown in the figure below, the sensors monitor the status of soldier as well as if anyone is attacking the soldier form rear in real time and if the intruder is detected the same will trigger the haptic feedback to the soldier in terms of vibrations which will be sensed in the jacket of the soldier. Additionally the jacket is equipped with different sensors which will monitor the real time status of the soldier and the same is pushed to the army base camp via internet using the IOT framework using the hardware equipped on the soldiers jackets. The different sensors include monitoring of the health parameters of the soldiers, detecting the damage status

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of the jackets in case of war, detection of explosions, fire, poisonous gases for gas hazards etc which are interfaced to the ESP32 controller board which will read the state of different sensors and update it to the cloud based IOT web application which serves as a base station for military tracking. The emergency assists system consist of the force tap sensor interfaced which can be activated when the soldier is in danger. The soldier in danger taps the sensor to get emergency help from the base station. Additionally the soldier GPS location as well as health status can be tracked on the army base camp using the developed system. The camera module is interfaced to the ESP32 controller which will be used capture the live video feed from the soldiers jacket and send it to the IOT base station which can be visualized remotely. The entire jackets are powered using solar energy, making it self sustained.

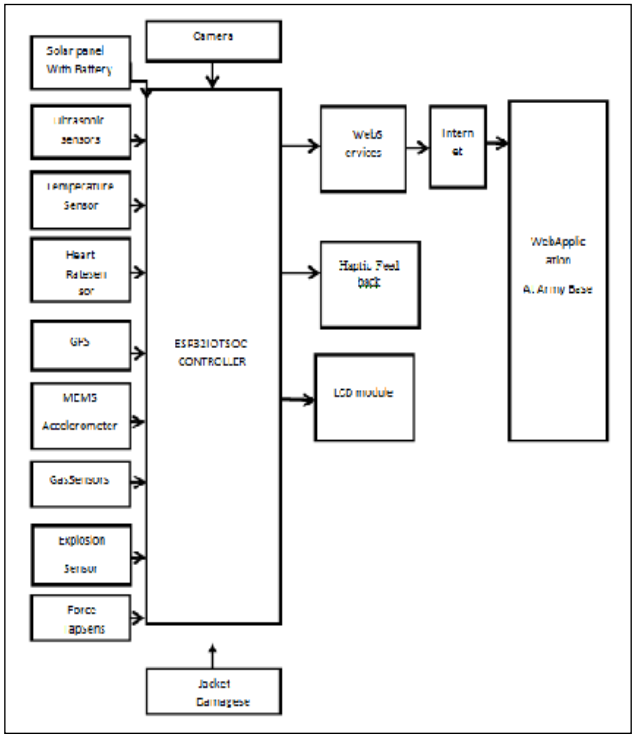

Figure 2

The following methodology is implemented through the course of the project. The entire project is carried out in different steps so that errors can be minimized at the end. The Methodology towards the conduct of the project is given below in terms of different phases.

- Literature Review and Market Study
- The Material Selection
- Development of Haptic Sensing and Alert systems
- Development of IOT framework for base station coordination
- Web application development and hosting it on cloud based system to send the data from the haptic soldier jackets to the cloud
- Interfacing Sonar sensor to detect the unexpected attacks from the soldiers
- Implementing fire and gas hazard zone detection system
- Development of emergency assist system to detect the soldier in danger and send Backup notification to the Base station
- Interfacing the camera to the ESP32 and Capturing live video feed
- Implementation of IOT protocols to send the Live video feed to the developed cloud application
- Development of solar energy based charging system to power the jackets
- Development of GPS based geo location alert systems
- MEMS implementation of soldier damage detection system
- Interfacing hardware and software
- Hardware Design
- PCB Fabrication
- Programming
- Assembly, Testing and Optimization

Components

GPS Module

The GPS module for Arduino and Raspbery Pi is a small electronic circuit that allows to connect to your Arduino/ Raspberry Pi board to get position and altitude, as well as speed, date and time on UTC (Universal Time Coordinated). It uses the standard NMEA protocol to transmit the position data via serial port. GPS Module for Arduino is a perfect complement for developing geolocalization applications.

The NEO-6M GPS module is shown in the figure below. It comes with an external antenna, does't come with header pins. So, you'll need to get and solder some.

Figure 3

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This module has an external antenna and built-in EEPROM. Interface: RS232 TTL

Power supply: 3V to 5V Default baudrate: 9600 bps

Works with standard NMEA sentences

The NEO-6M GPS module is also compatible with other microcontroller boards Pin Wiring

The NEO-6M GPS module has four pins: VCC, RX, TX, GND. The module communicates with the Arduino via serial communication using the TX and RX pins, so the wiring couldn't be simpler.

Table I

NEO-6M GPS Module	Wiring to Arduino UNO
VCC	5V
RX	TX pin defined in the software serial
TX	RX pin defined in the software serial
GND	GND

SONAR Sensor

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back.

It emits an ultrasound at 40 000 Hz which travels through the air and if there is an object or obstacle in its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance.

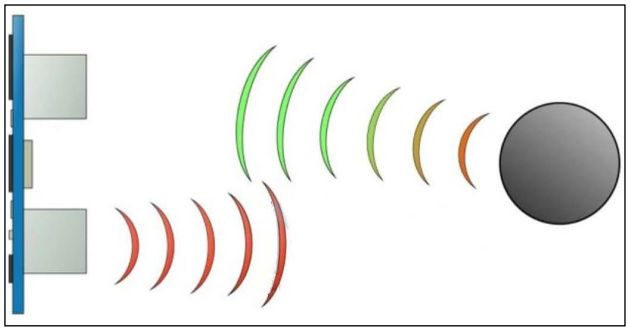

Figure 4

The HC-SR04 Ultrasonic Module has 4 pins, Ground, VCC, Trig and Echo. The Ground and the VCC pins of the module needs to be connected to the Ground and the 5 volts pins on the Arduino Board respectively and the trig and echo pins to any Digital I/O pin on the Arduino Board. In order to generate the ultrasound you need to set the Trig on a High State for 10 µs. That will send out an 8 cycle sonic burst which will travel at the speed sound and it will be received in the Echo pin. The Echo pin will output the time in microseconds the sound wave travelled.

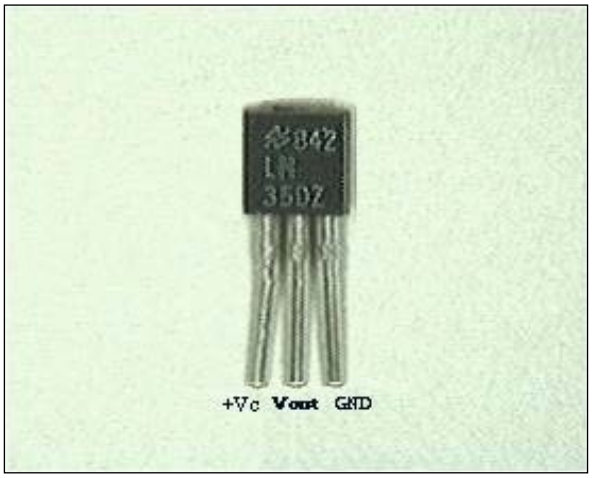

Figure 5

Temperature Sensor

The LM35 - An Integrated Circuit Temperature Sensor It has an output voltage that is proportional to the Celsius temperature.

The Scale Factor is .01V/^{O}C

The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 ^{O}C at room temperature and +/- 0.8 ^{O}C over a range of 0 ^{O}C to +100 ^{O}C.

Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1 ^{o}C temperature rise in still air.

An LM35 (Electrical Connections

Here is a commonly used circuit. For connections refer to the picture above

In this circuit, parameter values commonly used are

V_C = 4 to 30v

5v or 12 v are typical values used

$R_a = V_C / 10^{-6}$

Actually, it can range from 80 K to 600 Kbut most just use 80 K

Heart Rate Sensor

Figure 6

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Heart rate data can be really useful whether you're designing an exercise routine, studying your activity or anxiety levels or just want your shirt to blink with your heart beat. The problem is that heart rate can be difficult to measure. Luckily, the Pulse Sensor Amped can solve that problem!

The Pulse Sensor Amped is a plug-and-play heart-rate sensor for Arduino. It can be used by students, artists, athletes, makers, game & mobile developers who want to easily incorporate live heart-rate data into their projects. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications.

Simply clip the Pulse Sensor to your earlobe or finger tip and plug it into your 3 or 5 Volt Arduino and you're ready to read heart rate! The 24" cable on the Pulse Sensor is terminated with standard male headers so there's no soldering required. Of course Arduino example code is available as well as a Processing sketch for visualizing heart rate data.

MEMS Accelerometer

ADL345 digital Accelerometer is used in this project

Figure 7

An accelerometer is an electromechanical device that is used to measure acceleration and the force producing it. Many types of accelerometers are available in the market today. They can be divided according to the force (static or dynamic) that is to be measured. Even today, one of the most commonly used one is the piezoelectric accelerometer. But, since they are bulky and cannot be used for all operations, a smaller and highly functional device like the MEMS accelerometer was developed. Though the first of its kind was developed 25 years ago, it was not accepted until lately, when there was need for large volume industrial applications. Due to its small size and robust sensing feature, they are further developed to obtain multi-axis sensing.

Vibration Sensor

The vibration sensor, which is useful for a variety of different fields, has the ability to detect vibrations in a given area. This can help to alert someone to trouble with a system, you will even find these types of sensors in use with security systems today.

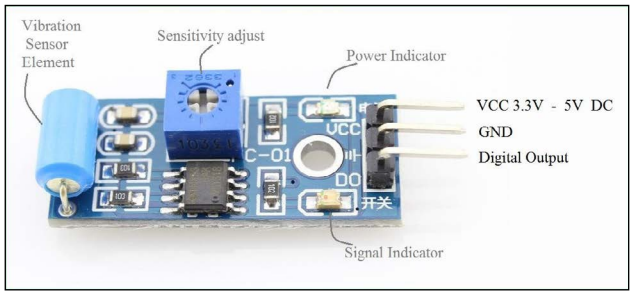

Figure 8

The vibration sensor SW-420 Comes with breakout board that includes comparator LM 393 and Adjustable on board potentiometer for sensitivity threshold selection, signal indication LED.

This sensor module produce logic states depends on vibration and external force applied on it. When there is no vibration this module gives logic LOW output. When it feels vibration then output of this module goes to logic HIGH. The working bias of this circuit is between 3.3V to 5V DC.

Gas Sensor

Gas sensor is used to detect and alert harmful gases when the soldier is on the field. MQ135 Gas sensor is used in this project. When a gas interacts with this sensor, it is first ionized into its constituents and is then adsorbed by the sensing element. This adsorption creates a potential difference on the element which is conveyed to the processor unit through output pins in form of current.

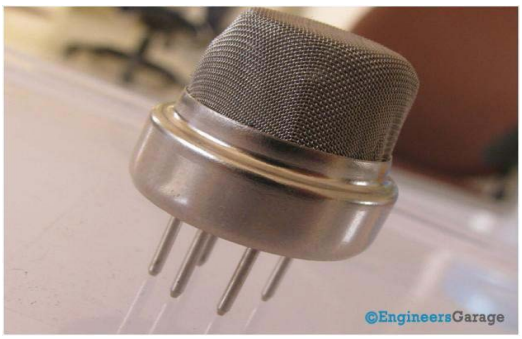

Figure 9

This sensing element is subjected to current through connecting leads. This current The gas sensor module consists of a steel exoskeleton under which a sensing

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element is is known as heating current through it, the gases coming close to the sensing element get ionized and are absorbed by the sensing element. This changes the resistance of the sensing element which alters the value of the current going out of it.

LCD Display

The 16x2 LCD used in this experiment has a total of 16 pins. As shown in the table below, eight of the pins are data lines (pins 7-14), two are for power and ground (pins 1 and 16), three are used to control the operation of LCD (pins 4-6), one is used to adjust the LCD screen brightness (pin 3). The remaining two pins (15 and 16) power the backlight.The details of the LCD terminals are as follows:

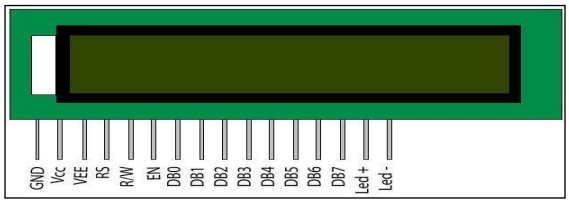

Figure 10

Vibration Motor

Vibration motor is used to alert the soldier when there is an unexpected attack. Vibration motor is a compact size coreless DC motor used to informs the users of receiving the signal by vibrating, no sound. Vibration motors are widely used in a variety of applications including cell phones, handsets, pagers, sooon.The main features of vibration motor is the magnet coreless DC motor are permanent, which means it will always have its magnetic properties (unlike an electromagnet, which only behaves like a magnet when an electric current runs through it); another main feature is the size of the motor itself is small, thus light weight. Moreover, the noise and the power consumption that the motor produce while using are low. Based on those features, the performance of the motor is highly reliable.

Figure 11

Camera Module

The WiFi Camera module is used to capture the soldiers environment and send it to the controlling end.The ESP32-CAM is a very small camera module with the ESP32-S chip. Besides the OV2640 camera, several GPIOs to connect peripherals, it also features a microSD card slot that can be useful to store images taken with the camera or to store files to serve to clients.

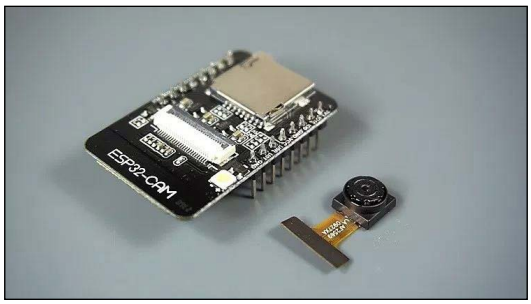

Figure 12

ESP32 Controller Board

The primary control board used in the project is ESP32 control board.

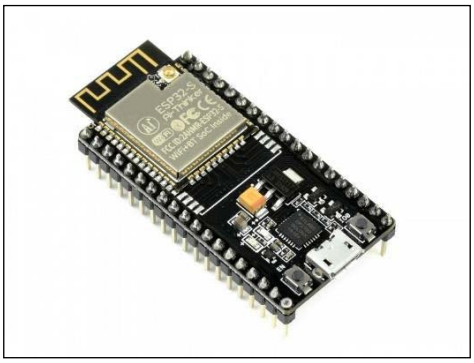

Figure 13

This is the NodeMCU development board based on ESP32, features WiFi+Bluetooth connectivity, onboard CP2102 and keys. What's more, all the I/O pins of ESP-WROOM-32 module are accessible via the extension headers.

Thanks to the rich open-source resources, it supports development in various ways such as Lua/AT commands/ MicroPython/Arduino/IOT source code, etc. helps you to fast prototype IoT applications.

FSR- Force Sensitive Resistor

This is used by the soldier to tap in case of emergency. FSRs are sensors that allow you to detect physical pressure, squeezing and weight. They are simple to use and low cost. This sensor is a Interlink model 406 FSR with a 38mm square sensing region. Note that this sensor can't detect where on the square you pressed (for that, check out our ribbon soft pots or capacitive touchpad).

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FSRs are basically a resistor that changes its resistive value (in ohms Ω) depending on how much its pressed. These sensors are fairly low cost, easy to use but they're rarely accurate. They also vary some from sensor to sensor perhaps 10%. So basically when you use FSRs you should only expect to get ranges of response. While FSRs can detect weight, they're a bad choice for detecting exactly how many pounds of weight are on them.

Figure 14

Flame Sensors:

Flame sensors are used to detect the explosion in front of the soldier. The flame sensors consist of Infrared sensors. Infrared (IR) light is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometers (nm) to 1 mm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz. Most of the thermal radiation emitted by objects near room temperature is infrared.

Figure 15.IRSensor

Software Used

Table 2

S.No	Software	Specification
1	Brackets	IOT control panel development
2	Easy EDA	PCB Design
3	Arduino IDE	Jacket Programming
4	Wamp Server	For Backend Development

The following software stack has been used in the project This section details the software used in this project. The table shows the software used for the development of the project. Their specifications are given in the section below.

Outcomes

The above project deals with smart haptic jackets for soldier assist and rescue. From this project we can expect that the above project forms an better solution for unexpected attacks which are happening on the soldiers from rear by detecting the enemy intruders form rear and providing haptic feedback to soldier so that he can be notified in advance regarding the surprise attacks from rear.

Also the IOT framework for soldier tracking will send the real time status of the soldier including the fall detection and body parameters to the Base station using the developed IOT framework which can be accessed from anywhere around the world. Thus we can conclude that this project forms a solution to assist soldiers as well as helps the base station to keep a track of individual soldier as well as health of individual soldier.

The project is also expected to capture the live video feed using the camera placed on the soldiers jacket and send it to the base station using IOT Protocols so that the base station can get the idea about the current environment in which the soldier is. Thus the proposed system is expected to solve the problems faced by the soldiers in various operations by providing them with smart jackets which will guide them on field as well as keep them connected with the base station using IOT to send all the stats and receive backup immediately when required.

Applications

- Can be used by soldiers on mission so that the system can assist them all the time
- Can be used by security personnel deployed in safeguard of high security areas
- Can be used by Police Officers in covert operations
- Can be used in counter attack related situations

Advantages

1. The proposed system can save the soldiers from unexpected attacks thus saving their precious lives.
2. The proposed system can link the soldiers to the base camp 24 x 7 thus proving them support at every point of time.
3. The developed IOT based system helps the controlling base to keep a track and visualize the status of every soldier on war field.
4. The GPS based navigation systems can help the base station track the soldiers location precisely.
5. The soldier danger situations can be detected using

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Tap and fall detection systems and thus soldiers can access the help with ease.

6. The camera based system can help the base station track the environment in which the soldier is by visualizing the video feed directly from the soldiers jacket.
7. Since the system is solar powered it takes the requisite energy to power the jackets from the sun.

Disadvantages

1. GPS data required non cloudy environment and accuracy may vary depending on the number of satellites available.
2. The secure encryption should be implemented in future as the project is defence related project and has the probability of data leak.

Conclusion

The above project deals with smart haptic jackets for soldier assist and resuce. From this project we can conclude that the above project forms an better solution fo unexpected attacks which are happening on the soldiers from rear by detecting the enemy intruders form rear and providing haptc feedback to soldier so that he can be notified in advancew regarrdin the surprise attacks from rear.

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Future Scope

The project also has wide scope for further improvements. The project can be implemented with deep learning and face recognition techniques in future to find the type of enemy attacking

from behind. Also the project can be implemented with automatic shooting or immobilization of enemies using tranquilizers if detected.

References

1. Hwang T, US Army Field Jacket Development in Response to Material Shortages and the Exigencies of World War II, *University of Pennsylvania Article* 2012; 3(1).
2. Scataglini S, Andreoni G, Gallant J. A Review of Smart Clothing in Military, Conference Workshop on Wearable Systems and Applications 2015.
3. Asistant professor Sridevi SH, Amit Dobade, Rohit Phulmali, Rahul Sinare, Solar Based E-Uniform For Soldiers, *International Research Journal of Engineering and Technology (IRJET)* 2017; 4(5).
4. Sahin 0, Kayacan E. Yazgan Bulgun, Smart Textiles for Soldier of the Future*, Defence Science Journal* 2005; 55(2): 195-205. DESIDOC
5. Sabarish Ch, Reddy RS, Solar Powered Thermal Jacket For Soldiers in Extreme Temperatures, *International Journal & Magazine of Engineering, Technology, Management and Research* ISSN No 2348-4845.
6. Engr Zeeshan Raza, Kamran Liaqu, Monitoring of Soldier's Health and Transmission of Secret Code, The sixth international conference on innovative computing IEEE explore, Dublin, Ireland.
7. Shruti Nikam, Supriya Patil GPS Based Solider Tracking andHEALTH Indication Systemº *International Journal of Advanced Research in Electrical Electronics and Instrumentation Engineering* 2(3): 2013.
8. Patil S, Prasad V. GPS based Soldier Tracking and Health Indication System. *International Journal of Electronics Communication and Computer Engineering*. 2014; 5(4): Technovision ISSN 224071X MAJ Phillip G. Burns . The Combat-Wireless Health Monitoring System , 21st Century Defense, US Army, 2010.
9. Mr. Rajdeep Limbu , GPS Based Solider Tracking and Health Monitoring system. *International Journal For Technological Research In Engineering* 1(12): 2014.
10. Govindaraj, Sindhuja Banu GPS based soldier tracking and health indication system with environmental analysis *International Journal of Enhanced Research in Science Technology & Engineering,* ISSN: 2319- 7463 2013; 2(12): 46-52.

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