AIOT based Real Time Environment Monitoring and Tracking System for Soldiers using SN-MQTT Protocol

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Abstract. In the crisis filled world, it is necessary to protect our Country and its resources. Where a strong military force will enable in safeguarding the nation security, wealth and our valuable lives too. Soldiers are not only involved in providing protection against the military attacks but also plays a crucial role in resolving problems thereby maintaining prevalence of peace in the country. Therefore, it is necessary to safeguard and protect soldiers from dangers as they are the guardians to enrich the prosperity of one’s country. The proposed project focuses on monitoring the soldier’s environmental attacks like detection of gun firing attacks, toxic gas detection, and emergency alert in case of threats. Followed by creating a virtual fence using Global Positioning System (GPS) to track and guard them within the safer zone and with inclusion of two-way wireless communication between the soldier & the surveillance unit using Wi-Fi Module in case of emergency return from the battle field thereby protecting them from the possibilities of danger. The technologies in particular Artificial Intelligence of Things i.e. the collaboration of Internet of Things (IoT) with deep learning (RNN-LSTM Model) helps in achieving information transfer between soldier and administrator followed by prediction of toxic gas presence in the atmosphere. The Administrator at the surveillance unit will monitor the real time status of the soldier in the webpage created using Node Red Programming Tool where the data are carried out by means of Sensor Networks - Message Queuing Telemetry Transport Protocol (MQTT). Thus this system ensures the security of the soldier.

Keywords - Soldier, Surveillance Unit, Monitoring, Environment, MQTT, RNN, Sensor, Geofence.

1. Introduction
Soldiers are one of the pillars for Nation’s security. Soldiers protect their country people in the borders despite of hardships they face. Every soldier plays a key role in maintaining the secrecy of Nation and delivering honour to the country. They serve for the welfare of the people in spite of knowing the risk they may face in their own lives. Some of the problems faced by the soldier is they were not able to determine their location and impotent to decide whether they are under the protected zone or not. And then deficit of monitoring the environment security level and status of the soldier in the war field. The project aims to furnish security to the soldiers and surveilling them from risk by addressing the above difficulties in the following manner, by designing an automated environment monitoring and guidance system for soldiers using Recurrent Neural Network (RNN) model, providing security for war fighters by determining the geographic areas and boundaries, helping the soldier in emergency situation by intimating to the control room administrator using IoT followed by detecting the gunshot attacks and...
notify about the external threats to the headquarter. All these are achieved by utilizing a light weight and low power connecting Message Queuing Telemetry Transport (MQTT) protocol for exchanging information among the devices.

2. Literature Survey

The works related to the areas of health monitoring, alarm notification based on data gathered and tracking location system using IoT devices and networks for military is described in this section.

The model described by AashayGondaliaa et.al is a bio sensor system used for monitoring the physiological status of soldier like temperature, heartbeat and GPS to track the location under LORAWAN network infrastructure [1]. They utilized k-Means clustering Algorithm for data analysis which is uploaded on the cloud.

Patiet.al discussed the health monitoring and tracking system for soldiers using Internet of Things [2]. Here information gathered is transmitted to the control room through IoT. It is a wearable tiny device embedded with sensor and transmission modules.

The work presented by DineshKumarJaiswar et.al utilized a system using wireless body area sensor network to observe the health condition like temperature, heartbeat level followed by tracking the current location of the soldier [3]. The Zigbee module is used to transmit the data from the sensors and GPS receiver in wireless manner. It is also incorporated with buzzer to notify the fellow soldier about the danger.

James Jing Kang et.al reported a wearable health device to measure the health parameter of the soldier using multi-layer interference system there by potentially conserving the battery power of the sensor devices [4]. The device is also equipped with an enhanced authentication mechanism using data related to health and using biometrics for personnel identification. The alarm notification module and actuation module in this system provides alarm notification to the rescue team and assistance to the soldier.

AfeMdhaffaret.al presented a low cost, low power and secure communication way to communicate the health status of soldier using IoT and LORAWAN network infrastructure [5]. Here the blood pressure, glucose and temperature is measured and monitored especially for the rural peoples where it minimizes the pressure to visit hospitals located in the farther regions thus reducing the transportation cost.

The work presented by Govindaraj et.al utilized a GPS based approach in tracking the location and the bio-medical sensors for health signs of soldier along with the analysing of environment using Barometric sensor, webcam and oxygen level detector [6]. A high speed, short range RF module is used in this system to relay the situational awareness and tactical instruction to the control room.

Dias et.al discussed a wearable device to determine the health factors which can be worn as a smart T-shirt to analysis the vital sign [7]. The paper focussed to help people in monitoring the health status during activity and fitness level. Therefore, the clinicians find helpful in diagnosing the problem related in earlier stage and suitable guidance for treatment.

Kang et.al proposed a described a feedback system in attaining the accuracy in alarming situation of the soldier by recognising the activity of them [8]. As a result, precise health factor is obtained thereby eliminating the false alarm using user feedback mechanism and reducing the number of transaction and transmission. The device also communicates with the physician to get knowledge about the health of soldier.

Arushi Sharma et.al discussed the method to health army personnel in deciding plans for war strategies by using the health status of the soldier [9]. The sensor unit comprises of flex sensor, humidity sensor, Temperature sensor, heart beat sensor and metal detector. The main purpose of the flex sensor is to communicate with the control room using specific gestures.

Tanvi shah et.al presented an IoT based location tracking using GPS and GSM module followed by monitoring the health condition like heart beat rate and temperature of soldier using Node MCU [10]. The device uses Wireless Local Area Network for establishing communication and utilizes Advanced Encryption Standard (AES) for encryption of the medical data in the database.
Friedl et al. discussed the physiology of soldier in real time and focussed on operational medicine priorities and producing a soldier’s fitness report upon analysing the fitness cognitive status, thermal work strain limit and musculoskeletal fatigue limits, neuropsychological status, and mission-specific physiological status [11].

Choo et al. described a model which uses authentication approach for accessing military/battlefield application by exercising the biometric system through cloud computing [12]. The concept helps to secure the weapons, vehicles and other equipment based on the identity and contextual data i.e. sensor status, application status, environmental data can be hidden by means of context-adaptive unlocking through edge computing. All the above research works focuses on monitoring the health of soldier but did not explain in monitoring the environment for planning defensive actions. Some paper used GPS only for tracking location but did not introduce Fencing for safer navigation.

3. Proposed Methodology

The proposed system helps soldiers in monitoring environmental conditions, tracking their location and also provides suitable instructions for safer navigation. Arduino Mega is used in designing the soldier monitoring environment system. The information’s gathered includes the parameters like heartbeat in beats per minute, Position in terms of latitude and longitude, toxic gases like NH3, NOX, Benzene and smoke in ppm and sound intensity of gun fire. The Route and the position information of the soldier is transmitted to the Surveillance Unit in real time, so that suitable war strategies can be undertaken by Administrator in Control Room. Pulse Rate Sensor gives the heart rate in beats per minute by measuring the rate of flow of blood at the fingertip. Gas sensor detects the concentration of poisonous gas in the atmosphere. The system also includes the GEO fencing concept where it uses a GPS module for tracking their current position and notifying the soldier automatically if he gets deviated from the safer zone and enters the enemy line.

The latitude and longitude position of the soldier is collected using GPS Module and is transmitted to the cloud using MQTT protocol and suitable intimation is given in the LCD display unit about their deviation. The gas sensor is used to detect the toxic gas level concentration in the field. Using the Deep Learning Recurrent Neural Network model, the environmental gas level conditions is predicted with the help of obtained GPS and gas level data and suitable instruction is provided to the soldier about the decrease in oxygen level that may happen using the LCD display unit thereby providing guidance. Thus the proposed paper helps in finding the heart rate, gas level, position, location parameter of the soldier using sensors and processed by Arduino continuously and transmitted via Wi-Fi Module using SN-MQTT protocol. This information is stored in the cloud and utilized to provide appropriate commands. Finally, an alert system using switches is added to notify the rescue troops and commander in case of threats and high emergency. The various blocks involved in this proposed system is explained as follows.

![Figure 1. Architecture of the proposed project](image-url)
The proposed block diagram shown in the figure 1 comprises three sections they are soldier unit, intermediate stage and surveillance unit. Hardware blocks present in the soldier unit is explained in the following section. The hardware part consists of Microcontroller, Sensor, Wi-Fi module and display which is illustrated in figure 2.

![Figure 2 Soldier Unit](image)

Arduino Mega is the microcontroller which is the heart of the hardware unit used in processing the sensory inputs. The Sensors incorporated to achieve the objectives are Pulse Rate Sensor, Air Quality Sensor, Sound Detector Module, and Global Positioning System Module. Changes in the volume of blood flow in arteries helps in calculating the heart rate of soldier by employing the Pulse rate sensor Module. The Air quality sensor finds the presence of toxic gases utilizing the SnO2 sensing element. Sound detector finds variation in the sound intensity with respect to the threshold thereby determining the firing event. The GPS module provides the latitude and longitude coordinate for ensuring whether the soldier is located within the prescribed safer zone. For transmitting as well as receiving the signals Wi-Fi Module helps in establishing the wireless communication between the hardware unit and surveillance unit. A flat panel display i.e. Liquid -Crystal Display is fixed to show the output of every sensor.

The intermediate stage consists of clout IoT, MQTT and Internet. Cloud IoT is a massive network providing services to IoT devices and applications for managing, connecting and securing IoT devices. MQTT is a publish-subscribe protocol for messaging and data exchanging of the IoT. Internet uses TCP/IP Internet protocol suite for communication and information sharing between devices. The surveillance unit which includes monitoring PC and Node red dashboard. For analysing and monitoring the soldier status personal computer with internet connectivity is used. Node- red is a tool used at the control room to display data visualizations in a way that is immediately understood. It has the built in graphical user interface that allows commander to interact with electronic devices owned by the soldier through the graphical icons.

### 3.1 Hardware Implementation

The physical arrangement of the wires and the components interfacing is depicted in the figure 3. The software and hardware components with specification is explained as follows:
Figure 3 Circuit diagram for proposed system

Hardware Components with Specifications

- Arduino Mega (ATmega2560)
- Pulse Rate Sensor (MAX30100)
- Sound Detector Sensor Module (REES52 LM393)
- GPS Module (NEO-6MV2)
- Air Quality Sensor Module (MQ135)
- Wi-Fi Module (ESP8266)
- Alert Switch (Tactile Switch)
- LCD (16x 2)

3.2 RNN Algorithm for Toxic Gas Prediction

The Recurrent Neural Network (RNN) is a Neural Network applied to predict the output depending on the current input and the previous state [13,14,15,16,17]. This is achieved through python which is a high level programming language.

The procedures involved in prediction of toxic gas present in the environment using RNN model includes collection of GPS location and Co2 Sensor Values from the sensors and store those values in the excel sheet as shown in the figure 4, Pre-processing and Generation of 2D model using those data followed by data validation for GPS and Co2 values, Applying Recurrent neural network (RNN) – LSTM, Creating new GPS value for prediction followed by prediction the toxic gas value for the new GPS location and Evaluating the results of accuracy, loss using Mean Squared error and other parameters. The python libraries employed in performing the RNN- Long Short Term Memory (LSTM) comprise of keras, pandas and numpy.
Figure 4 Data Sheet with latitude, longitude and Toxic gas values for particular location

3.3 Geofence Approach

Figure 5 Map with Bounded Region for Geo fencing
Geofence is virtual boundary created by a predefined set of coordinates potentially helps to finding whether a person is located within the defined perimeter. The figure 5 illustrates the bounded region created for Raja Lakshmi Engineering College, Chennai. The steps carried out in generating the geofence is as follows, Initially Geofence Area is created by fixing the coordinates using polygon method, then to check whether the soldier’s current location (Latitude and Longitude values) is present within the defined geo-coordinates. If the soldier leaves the bounded region alert notification is provided via LCD of the Soldier Unit.

4. Results and Discussion
The implemented project helps in monitoring the soldier’s environmental features that includes toxic gas estimation, sound detection during firing events, determining the health status followed by location tracking and providing Geofence thereby protecting soldiers from danger scenarios. The below figure 6 shows the final outcome of the proposed system which consists of Arduino Mega 2540, ESP8266 Wi-Fi Module, NEO-6MV2 GPS Module, Pulse Rate Sensor, MQ135 Gas Sensor, Sound Sensor and Alert Switch, Liquid Crystal Display, Light Emitting Diodes (Red and Green coloured LED), Voltage divider circuit and Power supply module.

![Figure 6 Hardware Implementation for Soldier Unit](image)

The following figures (7-11) shows output of the hardware component and the sensor readings observed on the LCD screen present in the soldier unit.

![Figure 7 Heartbeat of the Soldier in BPM](image)
Figure 8 Sound Intensity denoted as S

Figure 9 Air quality sensor output (Toxic gas detected (G), predicted output)

Figure 10 Geo fence Alert & latitude and longitude values

Figure 11 Emergency Messages

The figure 12 shows the webpage with gauge meters, map and icon. The gauge meters are used to indicate the sensor values of pulse rate module, sound detector and air quality sensor in pictorial way as well as in textual form. Each colour in the gauge meter states the levels of severity. Where the red indicates high abnormality, yellow refers to medium and green for normal stage obtained from each sensor modules. Switch icon (Emergency-Return Alert to Soldier) in the dashboard helps to convey return alert information and to relay situational awareness to the soldier. Map in the dashboard
functions as a hyperlink to locate the latitude and longitude values obtained from the GPS module. The figure 13 represents the prediction output for toxic gas with respect to the current location over a period of time.

Figure 12 Dashboard with Gauge meter, Icon and Map.

Figure 13 Prediction output for toxic gas estimation using RNN model

5. Conclusion
The proposed system helps to observe the surrounding atmosphere i.e. environment of soldier and assist the soldier to get aid from Surveillance unit or from rescue troops in case of emergency which may arise in the war field. This approach also provides the position and environmental parameters of soldier to the Surveillance Unit for planning war strategies and providing guidance to soldier in real time. Thus, this system ensures a highly reliable life guarding device thereby furnishing security and situational awareness to the army personal. The proposed work can be extended further by implementing bio medical sensors to determine psychological as well as physiological status of the soldier followed by addition of Gyroscope and Accelerometer together in recognizing the activity of soldier through machine learning algorithms and weapon control, other military equipment by means
of soldier’s unique identity. Thus meeting the demands using the above methods will empower the military field to greater extent.

6. References

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