A Military Surveillance System

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Abstract

Another critical role within the defence system is played by soldiers. Ensuring their security in the combat area should be of primary concern. One of the major problems in today's military confrontations is keeping an ongoing connection and awareness of the situation, which will reduce the need to carry out search and rescue missions for soldiers, affecting both their physical and mental health. In this research, the use of a Military Surveillance System using IoT and LoRa WAN is proposed to provide safety and efficiency in soldier operations by tracking each soldier based on their actions in the field operations or night-time area patrols. It allows for real-time tracking of the soldier's physiological vitals, location, and environmental factors, detecting any environmental changes and their impact on the soldier. It also provides secure and long-distance communication between the soldier and the base station. As a result, the headquarters receives complete information about the field environment, making decisions faster and more efficiently, ultimately leading to fewer losses and higher chances of successful mission outcomes.

INTRODUCTION

Security plays an important role for nation, individual life, and organisations. Secure environment or personal security are the basic concerns of human beings for work, for living. Providing a secure environment for human being there are multiple private and government organizations work in day-to-day life, such as the police, firefighters, and the military, mainly huge organizations work for safety and security concerns. Army operates under high risks since they operate close to the border areas where security becomes a main problem. War and international conflict situations require constant attention from soldiers. Soldiers become key players in the context of ensuring national security with their operations taking place under terrestrial conditions

Major research is being done by some of the world's largest militaries like India, the United States, the European Union, and China, to build wearable surveillance devices which could monitor physical and environmental factors of soldiers. India launched SANJAY Battlefield Surveillance System in January 2025. The European Defence Agency (EDA) works on large-scale AI Surveillance projects.

Surveillance system makes it easy for the soldiers to know several parameters such as their location, surrounding conditions, health conditions, etc. It provides a simple-to-use interface. They can get assistance from the base through the wearable device and at the same time a log is created about those parameters

METHODOLOGY

System overview

Our idea was to bring a wearable device to provide surveillance of a soldier with information acquisition from his context. Device contains sensor network, LCD, communication device to acquire information from soldier side and send to base camp of soldier regiment.

Based upon the essential performance, power consumption, reliability, cost-effectiveness and ability to operate in "real-time" under challenging environmental conditions, components were selected for the hardware associated with the proposed Wearable Soldier Surveillance System.

First, the primary processing unit will be a Raspberry Pi 3 Model B+ because of its very high power-positional processing capability, integrated Wi-Fi and Bluetooth networking, the ability to simultaneously process sensor and camera data, etc. In general, the Raspberry Pi should have better

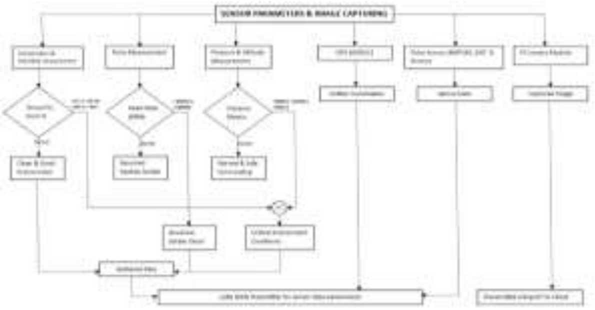


Fig. Surveillance System workflow

performance than traditional microcontroller devices (i.e. Arduino) for higher-order IoT-based applications. The environmental monitoring will be accomplished using the DHT11 temperature/humidity sensor. The DHT11 was selected due its lower cost, ease of interfacing, and generally adequate tolerance over more expensive temperature/humidity sensors for use in a wearable device. The BMP180 was incorporated into the proposed system to provide a very accurate measurement of atmospheric pressure and altitude with low power consumption, an essential requirement for analysing different environmental conditions in different types of terrains.

The Raspberry Pi camera module allows for visual surveillance to be conducted easily as it is able to integrate directly with the Raspberry Pi, has a smaller size and uses less power than USB cameras, thus allowing live capture of images while in the field. The use of a GPS module allows for accurate real-time location tracking of a soldier and is a necessary element for aiding navigation and responding to emergencies by providing real-time positioning of each soldier. A pulse sensor is used to monitor the soldier's health status. The pulse sensor's small size, low power consumption, and ability to continuously monitor heart rate in real-time made it ideal for the system. An LCD with 16 characters by 2 lines has been used for the immediate display of vital parameters to the soldier. The advantages of this type of display are that it requires small amounts of power, provides a simple interface for displaying information, and it does not require significant amounts of power to operate and its very rigid as compared to other displays as considering rough use.

A LoRa WAN module has been selected for communication due to its extended transmission distance, low power consumption, and reliability when operating in remote areas or in areas with poor or no access to cellular or Wi-Fi networks, therefore making it the best choice for communication between soldiers in a battlefield environment, as compared to the use of GMS or Wi-Fi. Lastly, an IoT cloud-based platform is utilized to collect and store images captured by the camera module and see the captured images in real time at the command-and-control centres.

IoT Implementation

Through the use of the Google Drive API version 3, which is also authenticated using OAuth 2.0 credentials, the processed images are uploaded to Google Drive securely. Using the Raspberry Pi, we utilize the Python-based libraries *google-auth* and *googleapiclient* to streamline the process of automatically uploading files seamlessly. Within Google Drive, images are placed into folders based on their time stamp to promote modified data organization and ease of finding them. As well, it is important that the Google Drive cloud infrastructure has 99.9% uptime, easy expandability, and redundant storage locations so that they will consistently be available during continual military operations.

At the base station, authorized personnel will have the ability to access uploaded images through the Google Drive secure interface or through an integrated custom-built dashboard using the Google Drive API. The Google Drive webhooks will notify operators through real-time notification when a new image has been uploaded so that they will be able to promptly assess and respond to potential threats.

Communication System

Previous research on surveillance and IoT-based monitoring systems shows that traditional communication methods have several limitations, especially in remote or high-risk areas. Many existing systems use short-range communication technologies like Wi-Fi, ZigBee or Bluetooth. These technologies provide data rates but they have limited transmission range. Cellular-based communication, such as GSM, 3G/4G is widely used for transmitting sensor and image data. However these networks rely on existing telecom infrastructure. This infrastructure may not be available reliable. It may be disrupted in military scenarios. Another limitation of systems is that they use a single communication channel for transmitting both sensor data and multimedia content. There are also concerns about data security and scalability.

Communication between Sensors Using LoRa-WAN

For sending the information about the environmental parameters and any intrusions detected by the sensors (temperature, humidity, gas concentration, motion detection), the LoRa-WAN technology is chosen due to its enhanced transmission distance, low energy consumption, and reliable performance in remote and harsh conditions. The sensors are connected to the microcontroller that uses a LoRa transmitter/receiver to communicate with the central LoRa-WAN gateway. Additionally, LoRa-WAN allows using adaptive data rates (ADR) and AES-128 encryption.

Cloud-based Images Transmission over Internet

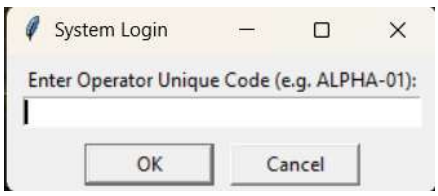
However, the LoRa-WAN protocol cannot be applied for transmitting large amounts of data such as photos. Therefore, the system uses a Raspberry Pi microcomputer with a built-in camera module. Captured photos are sent over the Internet to the IoT cloud server. Images are sent to the cloud periodically or based on some triggers, such as motion detection, which provides real-time remote monitoring. The IoT cloud acts as a database storing the photos captured by the cameras. The IoT cloud also offers visualization capabilities, giving access to the photos stored in it.

Receiving Base Station

The base station of the recommended system will be built to accept, process, and display data that will be sent by sensor nodes located at distances using LoRa-WAN communication technology. It consists of a LoRa receiver attached to a microcontroller unit (MCU), which will act as the processing hub. Data from the sensors will be collected by the LoRa receiver in form of data packets and sent to the MCU in a serial interface like UART.

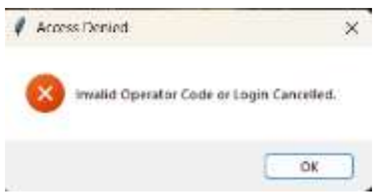
After decoding and processing the sensor data by the MCU to ensure data integrity, the data will then be transferred to a graphical user interface (GUI) system. Using this tool will make it easier to analyse and monitor various parameters of the sensor. With the GUI, a user can view sensor parameters as well as any alert issued by the sensors. This will make it easy to make quick decisions whenever a need arises.

GUI at Base Station



System Authentication Gateway

Depicts the first layer of security of the surveillance system. In order to have access to the main dashboard, the application requests an Operator Code that is pre-assigned and unique to each operator (for example, "ALPHA-01"). It guarantees only the correct person will be able to initiate the process of telemetry tracking and secure its corresponding datalink.



Unauthorized Access Protocol

Shows the defense mechanism of the system in case of any attempts of illegal access to the dashboard. Should the incorrect operator code be used or bypassing the login process occur, an exception of the type "Access Denied" will be thrown. This will prevent dashboard activation and securing asset telemetry from any leaks.

Active MAS Telemetry Console

Shows the primary Graphical User Interface (GUI) of Military Surveillance Systems (MAS) console on an active authenticated session (OPR: A01). The console features live telemetry tracking, which includes an optical feed, arc gauges of various environmental factors (temperature, humidity, atmospheric pressure), live biometric and altitude telemetry graphic representation, GPS positioning and datalink packet stream display.

Critical Anomaly Detection State

Describes the anomaly detection mechanism and visual notifications system of the application. Upon any parameters of the monitored hardware exceeding safe physiological or environmental thresholds – in this particular case it was the operator's heart rate reaching 111 BPM – the state of the system changed to "Critical". Red color was used to represent dangerous metrics at all relevant places in the GUI.

RESULT

The IoT-based Wearable Soldier Monitoring System was successfully developed and validated. The hardware node, which was controlled by a Raspberry Pi 3 B+ device, ensured accurate concurrent data collection. The environmental sensors (DHT11, BMP180) remained highly precise (variance $\leq \pm 2°C$, ±5% RH). On the other hand, the pulse and GPS modules offered reliable physiological and positional monitoring. The communication network design showed significant efficiency: the LoRa-WAN module guaranteed real-time data telemetry through AES-128 encryption with negligible packet loss; at the same time, the cloud-embedded IoT system ensured fast image telemetry with minimal delay. The MAS Base Station software successfully processed all data, providing lag-free data visualization and automatic anomaly detection (e.g., heart rate >110 BPM).

CONCLUSION

The proposed system involves a military surveillance system based on IoT embedded & WAN communication into wearables. The development of this system aims at overcoming some difficulties faced by the soldiers. System is a wearable tool that was created for use by soldiers to help them during combat. After the full development and testing of this system, System will play an essential role in the network-centric warfare strategy of the Army, connecting infantry soldiers with the Army command centre.

In summary, the suggested system represents a scalable, secure, and efficient method for modern military surveillance and soldier assistance, with possibilities for future development in automated decision-making systems and AI-based threat detection.

FUTURE SCOPE

Integration with AI: Machine learning algorithms could be implemented at the base station to analyse sensor data for anomaly detection (e.g., detecting if a soldier is under stress or injured).

Two-Way Communication: The system could be enhanced to allow the base station to send messages or alerts back to the soldier.

Miniaturization: The hardware components could be further miniaturized for a more compact and comfortable wearable device.

Mesh Networking: Implementing a mesh network of LoRaWAN nodes could extend the communication range even further, especially in challenging terrains

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