Smart Military Healthcare Monitoring and Tracking System on Raspberry Pi and Arduino

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***Abstract*— Although technology advances cannot help in limiting the dreadfulness of war, they can at least be deployed to reduce war effects and casualties. One way to help in this aim could be by tracking and monitoring the location and health situation of troops in the battle. The main objective of the work presented in this paper is to design and implement a complete tracking system that is composed of a mini portable server as a central unit hosted on a Raspberry Pi to read soldier's location, state, and health information through wireless communication from a small monitoring unit that is attached to the soldier's arm. Moreover, the system provides an emergency button that requests help when pressed if a soldier is facing an urgent problem. A set of test cases has been applied and the results achieved by our prototype have presented a promising accuracy and efficiency when applying such a system.**

Keywords—Healthcare monitoring; tracking system; Raspberry Pi; Raspbian; ESP8266; Arduino; Wifi communication.

I. INTRODUCTION

On September 28 1951, Daniel Hunt, 18, of Columbiaville was a member of Company A, 1st Battalion conducting operations near an area referred to as Heartbreak Ridge [2]. The Chinese launched an attack, which the company repelled. Prior to their attack, the Chinese launched a barrage of mortar fire against the Americans in which survivors withdrew to friendly lines. Hunt was reported missing in action. During an investigation by the U.S. Army Casualty office, three members of Hunt's unit reported that he had been killed during the fight, so the Army declared him deceased. Today, 7780 Americans remain unaccounted for from the Korean War [1]. Thousands of cases like "Hunt" are encountered around the world, showing that the issue of unaccounted soldiers is a common in war zones.

Some people believe that known military communication tools can help to avoid the above mentioned issue. However, natural factors, lack of knowledge about the battlefield, loss of connection between soldiers, power failure of these tools, barrage jamming and so on, constitute other obstacles for soldiers and their leadership.

These and many other problems have led researchers to think about new solutions benefiting from the evolution of technologies. Throughout the years, many technologies have been invented to solve the Missing-In-Action problem, but they remained weak. Most of these systems are based on tracking the soldiers' movements, which is not always an efficient way to detect the real situation on the ground. Navigation and situating are important, but need tiring activities which GPS (Global Positioning System) makes easier. The GPS has turned out to be a significant technology for the U.S. military and other defense forces around the world since the 1980's [2]. With the ability to provide accurate positioning continuously, day or night, in any conditions, GPS has helped ground troops in Iraq and Afghanistan navigate across expansive, barren deserts that have few markers or distinguishable features. Although GPS provides the position of soldiers in battle, it is still considered weak and far away from healthcare when any of health issues are faced during battle.

From all the above-mentioned issues, we arrived at the objective of our paper, which is designing a new "smart military healthcare monitoring and tracking system" that would significantly reduce the effects of problems encountered during the combat. Our system grants the leader the ability to track his troops on the map application and monitor their health statuses continuously in battle, even in advanced lines, by accessing the Web page directly from the small central server or by using a mobile application.

The rest of the paper is organized as follows. In Section II, we talk about some similar applications to our system. Section III gives an overview of the system architecture. Section IV talks about the used components and describes the implementation in detail. Section V summarizes the main contributions of this paper.

II. RELATED WORKS

Medically, health statuses of patients with critical conditions are a great concern for doctors who seek new and innovative healthcare systems. In the past, militarily armies monitored their soldiers with the aid of primitive communication systems, such as walkie-talkie, until the technological development enabled tracking systems using satellites.

A. Movement/traking system

The United States Army invented a Movement Tracking System (MTS) that is a logistics communication platform under the Program Executive Office (PEO) for Enterprise Information Systems (PEO EIS) [3]. It is designed for commanders to track assets on the battlefield with encrypted text messaging. It is a satellite-based tracking and communicating system designed to provide command and control between the leader and the soldiers.

This device can continuously monitor the soldier's location during battle, which improves the leader's control of the troops without the need for primitive communication tools which require manual usage. MTS's main disadvantage is that the health statuses of soldiers remain absent from such systems.

B. Smart systems for healthcare monitoring using communication means

Health monitoring systems have rapidly evolved recently, and smart different systems have been proposed to monitor patient's current health conditions. In a recent work [4], authors are proposing a "Smart real-time healthcare monitoring and tracking system using GSM/GPS technologies", which concentrates on checking the patient's blood pressure and body temperature. This system was built for social healthcare in light of GSM and GPS innovations and as a compelling application for real time health monitoring and tracking. In case of emergency, a short message service (SMS) will be sent to the doctor's mobile number along with the measured values through the GSM module. Moreover, the GPS gives the location data of the patient who is under observation all the time. While this system covers the issue of healthcare status provision, it cannot continuously track the person's required information. In addition, the usage of GSM to send short messages is more expensive and can face some mistakes, such as when the doctor's phone is out of service or due to man-made confusion (in the military case), etc.

In another work [5], authors proposed "Patient Health Management System". This system is based on smart devices and wireless sensor networks for real time analysis of various parameters of patients. This system is aimed at developing a set of modules which can facilitate the diagnosis for the doctors through tele-monitoring of patients. It also facilitates continuous investigation of the patient for emergencies looked over by attendees and caregivers. A set of medical and environmental sensors is used to monitor the health, as well as the surroundings, of the patient. This sensor data is then relayed to the server using a smart device or a base station.

Each of the systems discussed above provides a feature needed before, during and after a combat. MTS provides continuous tracking of soldiers' movements, but their health statuses are missing, "Smart real-time healthcare monitoring" system provides health statuses tracing, but not continuously, "Patient Health Management System" provides health monitoring using smartphones over The Internet or using servers to extract information.

In our design, we are trying to achieve the goals of existing systems by combining their features in one small wearable device. The importance of our system compared to other products is manifested in its ability to simultaneously keep an eye on soldiers' health status alongside their locations without the need for manual control, which facilitates leader-troops communication, even on the front line. Moreover, the central unit, unlike the systems discussed, is a small portable device to be held by the leader. It hosts the information locally without any need for huge servers or access points between soldiers and their leader.

III. SYSTEM OVERVIEW

As depicted in Figure 1, we have two main components. The first one is the central unit that plays the role of a server and it is usually controlled by the group leader. The second one holds the monitoring units worn by the soldiers in the battle.

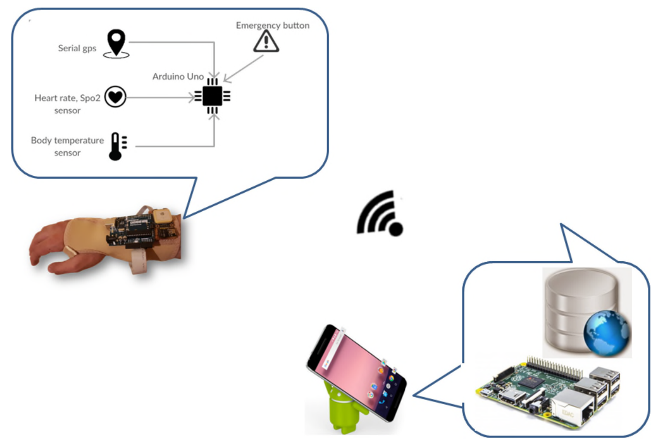

Figure 1. System Architecture diagram

The central unit will be portable with light weight and small size. For simplicity of connection, this unit could provide an access point to the soldiers to make sure no intermediate equipment is needed. This server will host all the needed information, such as the database and the Web pages. Hence, data retrieval will be done locally and no need for any external connection such as GSM or Internet will be needed. This will help in increasing the system security, connection speed and data localization, since the information of a group of soldiers does not need be be published on a large scale. This unit can be controlled via a Web application that could be accessed directly from it or via a mobile application that is designed to do the same objective. The other main component of our system is a small wearable glove that is equipped with all the sensors and detectors to connect soldiers to their operations campaign. This will be done by detecting body temperature, oxygen level in blood, heart beat rate, speed and location of each soldier. All this information will be sent periodically and automatically to the central unit notifying the commander of any issue, injury or maybe death. Additionally, our system provides an emergency button that

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gives the soldier the possibility to request help when facing a non-medical urgent problem.

IV. Implementation Tools and Details

A. *Monitoring unit implemetation*

In our system, the monitoring unit is composed of a microcontroller connected to a heart pulse sensor, oxygen level and body temperature sensor, serial GPS, emergency button, and ESP8266, as shown in Figure 2.

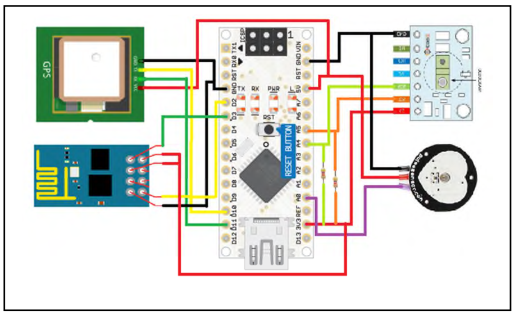

Figure 2. Monitoring unit implementation board.

The Arduino Uno is a small, complete, and breadboard-friendly board. It has 14 digital pins, and each of them can be used as an input or output. It also has 8 analog pins, each of which provides 10 bits of resolution.

We connected the heart pulse sensor to an analog pin of the microcontroller. The pulse sensor reads a waveform and calculates the BPM (Beats Per Minute), as well as the IBI (Inter Beat Interval), which is the time between beats [7].

The oxygen level and body temperature are both measured using the MAX30100 chip. The only required connection to the sensor is the I2C bus (SDA, SCL lines, pulled up). The MAX30100 is an integrated pulse oximetry, body temperature, and heart-rate monitor sensor solution [8]. The accuracy of the pulse sensor was better, so we ignored the heart rate value measured by MAX30100 and we used it as a supporter in case we have any fail in the heart pulse sensor.

In addition, we used NEO-6M GPS Module to measure the speed of each soldier beside his location as latitude and longitude values. The serial GPS communicates serially with the microcontroller. This GPS Module uses the latest technology to give the best possible position information. Also, it comes with ceramic antenna.

Finally, the microcontroller sends all measured values using serial communication to the Wi-Fi module which is connected to digital pins. The Wi-Fi Module (ESP8266) is programmed to get values from the microcontroller following a specific algorithm; then, it sends these values through WIFI to the central unit where the leader monitors. The ESP8266 is a self-contained system on chip with integrated TCP/IP protocol stack that can give any microcontroller access to any WIFI network. The ESP8266 is capable of either hosting an application or offloading all WIFI networking functions from another application processor.

B. *Central unit impelementation*

Raspberry Pi with Linux operating system is the central unit. The leader can browse the Web page built for the system to track and monitor his soldiers. In addition, we added a 7 Inch LCD touchable screen and a keyboard to allow the leader to access the Web site directly from the server. As shown in Figure 3, the central unit is a portable device with small dimensions (15cm width x 15cm height and less than 10cm depth) so the leader can hold it in the battle even in advanced lines and stay connected to his soldiers.

Figure 3. Portable central unit based on Raspberry Pi.

The original Raspberry Pi is a small computer with a processor, RAM (Random Access Memory) and graphics chip. It has various interfaces and connectors for external devices communication [9]. In our system, we configured it as a server. We used Raspberry Pi V3 Model B which has 512 MB of RAM.

C. *Web page and Android Application implementation*

Each soldier in the battle held a user-friendly wearable device composed of the microcontroller, sensors required and a WIFI Module. A real prototype of soldier's device is shown in Figure 4. The microcontroller gets all sensors' values and sends them to the central unit directly using WIFI signals without passing through any access point.

Each soldier must turn on his own device, which is programmed only for his unique id, without any need for any manual configuration. This device will send the soldier's id, health status and location information continuously. In addition, any soldier with normal health status can notify his leader by pressing an emergency button if he needs any help. The leader can track and monitor his soldiers directly from the small portable access unit, or any other PC connected locally to this unit, by accessing the Web page built for the system from any browser. After login, the Web page displays a map showing all the soldiers in the battle, as shown in Figure 5. The soldiers are represented by markers; the icon of a marker changes depending on the health status, or in case of an emergency. The leader can also use the Web page to add, remove, and view his soldiers and their personal information.

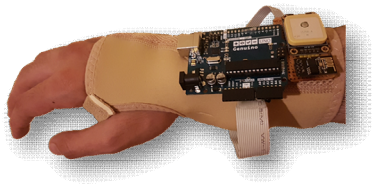

Figure 4. Soldier's wearable device.

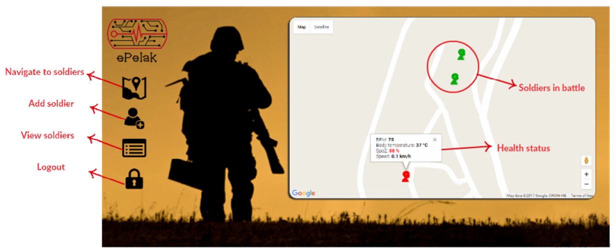

Figure 5. Main Web page shows soldiers on Map.

We developed an Android application to allow the leader to use it instead of the Web page to track and monitor his troops on a map, as shown in Figure 6. This application allows the leader to add and show soldiers health statuses and personal information displaying them in a list, as shown in Figure 7.

V. CONCLUSION

The main objective of this paper was to design and implement a complete system for monitoring and tracking soldiers' health information and location in a battle. Our system provides a wearable device for each soldier and a portable device for the leader. This enhances his ability of caring about the band benefiting from a Web page and an Android application. This system has a humanitarian aim since it can decrease the effects of many issues in battle including soldiers unaccounted for and the difficulty of health status monitoring. The system security can be addressed using encryption technologies, such as AES (Advanced Encryption Standard) for the data exchanged between the central unit and the soldiers. This system could be tested on real soldiers to prove its applicability. Another enhancement on the system could be by providing an agreed upon secret code to be sent with the emergency button in order not to abuse this facility by the enemy. Moreover, the range of the WIFI signals is limited 100 m, and the GSM cannot be used because its signals are weak in the battle area or they do not even exist. Our system can be improved by introducing a new communication system using microwave signals with frequencies lower than WIFI band (around 2.4 GHz).

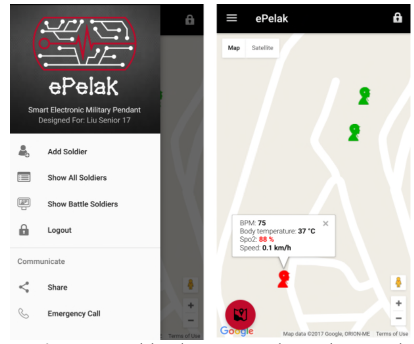

Figure 6. Maps and leader's control panel on Android.

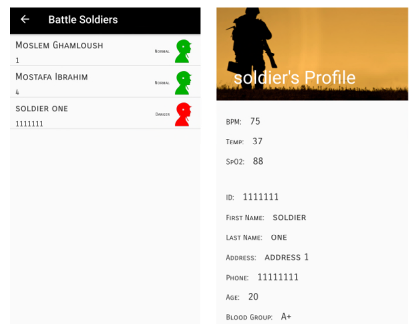

Figure 7: List of battle soldiers and their health.

REFERENCES

[1] Deffensive POW/MIA Accounting Agency. Soldier Missing From Korean War Accounted for Hunt. http://www.dpaa.mil/News-Stories/News-Releases/Article/1011148/soldier-missing-from-korean-war-accounted-for-hunt/ [retrived June 2017]

[2] S. Smith. GPS-An important technology to U.S. troops. https://www.thebalance.com/gps-an-important-technology-to-u-s-troops-3345076 [retrived June 2017]

[3] CPT Hilt, Jeffrey J.; SFC Jones, Ronald L. MTS: An Untold Commo Success Story in OIF. http://sill-www.army.mil/FAMAG/2004/SEP_OCT_2004/30-32.pdf [retrived June 2017]

[4] Kahtam A., Saed T., Salah H. Smart real-time healthcare monitoring and tracking system using GSM/GPS technologies. Big Data and Smart City (ICBDSC), 2016 3rd MEC International Conference on. 28 April 2016. Muscat, Oman

[5] Srijani M., Koustabh D. Soumya K. Patient Health Management System using e-Health Monitoring Architecture. Advance Computing Conference (IACC), 2014 IEEE International. 21-22 Feb. 2014. Gurgaon, India.

[6] Arduino Uno Overview https://www.arduino.cc/en/main/arduinoBoardUno [retrived June 2017]

[7] J. Murphy, Y. Gitman. Pulse Sensor Advanced" https://pulsesensor.com/pages/code-and-guide/ [retrived June 2017]

[8] Maxim, "Pulse Oximeter and Heart-Rate Sensor IC" https://datasheets.maximintegrated.com/en/ds/MAX30100.pdf [retrived June 2017]

[9] David Thompson, "Raspberry Pi 3 Model B" https://www.raspberrypi.org/products/raspberry-pi-3-model-b [retrived June 2017]