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Testing Environmental Sensors to Reduce Heat Ailments among First Responders

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Introduction

Over the last few years, there has been an increase in the number of deaths of the hazmat first responders mainly due to cardiac arrest, heat stroke, heat stress, lack of oxygen in the blood and inhalation of hazardous chemicals. National Fire Protection Agency (NFPA) statistics reveal the following:

- There were more than 30,000 firefighter injuries between 2010-2016.
- 42 percent of fatalities were caused due to physical stress and overexertion.
- The hazmat first responders face a 14 percent increase in cancer-related deaths (NIOSH).

Past research and interviews with various focus groups have indicated that there is a lack of real time health monitoring for first responders during a hazmat response. It is extremely important to monitor the health and environmental parameters surrounding the hazmat first responders in order to improve their safety and mitigate their deaths.

A decrease or an increase in the core body temperature of a hazmat first responder when exposed to extreme environmental conditions can result in adverse health effects such as heat stroke, cardiac arrest and heat exhaustion. Thus, my primary research goal is to monitor the temperature inside and outside the personal protection suit of first responder in order to improve their health and reduce risks associated when they are subjected to potentially harmful emergency hazmat situation. **This can be achieved through Internet of Things (IoT) sensor technology.**

Background

What is HAZMAT?

Hazardous Material (HazMat) is defined as **"**a substance or material, including hazardous substance, which has been determined by the Secretary of transportation to be capable of posing an unreasonable risk to health, safety and property when transported in commerce and which has been so designated". [1]

Who are first responders?

A **first responder** is an individual who would immediately be present at the scene during a HAZMAT emergency. They include the fire department, police department, emergency medical services and the department of environmental quality.

What is Personal Protection Equipment (PPE)?

It is a specialized clothing designed for the hazmat first responders to provide protection from serious injuries and illness resulting from contact with chemical, radiological, physical, electrical, and other hazards.

- Wearing a PPE (Personal Protection Equipment) puts a hazmat first responder at considerable risk of developing heat ailments. First responders are often subjected to working in extreme environmental conditions, where the temperature can be severely dry or wet.
- One of the main challenges of PPE is the inability to eliminate heat through radiation, convection and evaporation, where it impedes the wearer's ability to balance the heat production and heat dissipation. [4]
- This can result in degrading the health of the hazmat first responder with harmful conditions ranging from heat fatigue to serious impacts such as heat stroke and death.
- Heat exhaustion is characterized by an increased core body temperature (Tc > 98 º F) and increased heart rate (BPM > 100), which can result in causing dizziness, fatigue and low blood pressure in the first responder. If immediate action is not taken to cool the individual, high core body temperature can cause multi-organ dysfunction, which often leads to death.

Temperature and humidity affect the thermal balance of the human body via skin and the respiratory system. Thus, it is extremely important to monitor the temperature and humidity inside and outside the personal protection suit of the hazmat first responder when they are subjected to strenuous environmental conditions.

Research Purpose

The purpose of this research is to:

- Monitor the health parameters of the first responders in an emergency hazmat response through IoT sensors
- Improve their safety and reduce adverse heath effects
- Visualize the IoT sensor data for effective decision making

Acknowledgement

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Research Questions

- Can IoT sensor technology be utilized effectively and accurately to monitor first responders' core body temperature during a hazmat response?
- What is the best way to visualize IoT sensor data when monitoring first responders' core body temperature during a hazmat response?
- What is the best way to effectively send alert notifications to the hazmat first responder wearing a PPE when core body temperature is possibly too high?

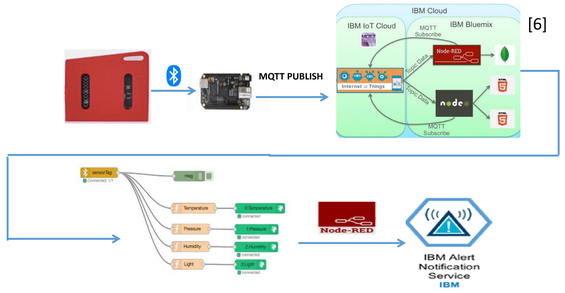
Solutions

- The advancements in Internet of Things (IoT) in relation to wearable sensors has enabled communication between human and things in various areas such as health monitoring, intelligent transportation systems, safety/security, environmental monitoring etc.
- The increasing need for health monitoring and preventive medicine has given rise to the development of numerous wearable devices which can be used to monitor health parameters such as core body temperature, heart rate, blood pressure, blood oxygen and movement. IoT sensors can be incorporated into computed devices to measure these health parameters and can be comfortably worn on the body.
- For our research, we will be using a Texas Instruments CC2650 – an ultra low power Bluetooth sensor tag which has the following sensors: Temperature, Pressure, Humidity, Accelerometer, Gyroscope and Magnetometer.

Technology

All the technological components used for our research are open-source software.

- Texas Instruments CC2650 – a low power Bluetooth low energy sensor tag
- IBM Watson IOT Platform – a cloud hosted service [3]
- IBM Bluemix – to build, manage and deploy applications on cloud
- Node.js – a platform to execute JavaScript code on the server side
- Node-Red – a visual flow based development tool



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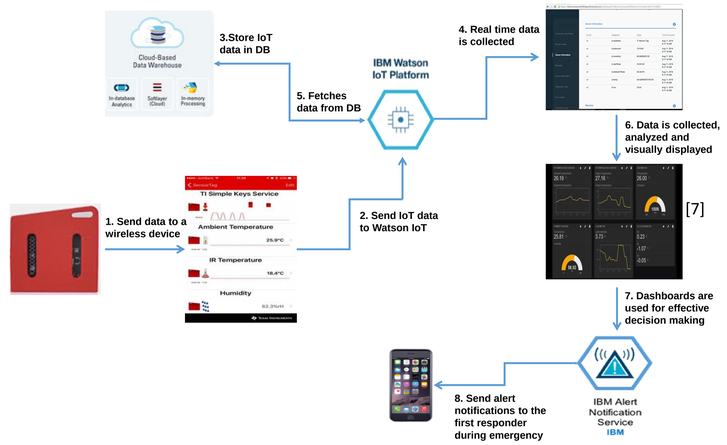
Integrating Sensor Data on IBM Watson IoT Platform



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Functionality

The functionality of the above diagram is described below:

- A low power TI Sensor Tag CC2650 is connected to a mobile device via Bluetooth low energy.
- The device pushes the sensor data onto the IBM Watson Cloud Platform via MQTT protocol.
- The sensor data is obtained is a real time environment and gets updated on the cloud platform every 3 seconds.
- Node.js application connects the TI sensor tag data to the IBM cloud platform.
- Once the data is received on the cloud, a Cloudant database such as dash DB is used to store and fetch the sensor data.
- A Node-Red app is used to analyze and react to the cloud sensor data. Various real time analytics and data visualizations can be performed using the Node-Red application.
- For our research we would be setting a threshold value for the core temperature and humidity; Thus if the threshold is met, additional data can be pulled from the Cloudant database to send alert notifications to the first responder during a hazmat response .

Future Work

- Build a mobile application to visualize sensor data and send alert notifications to the first responder during a hazmat response.
- Test the quality and accuracy of the IoT sensor placed inside the protection suit of the hazmat first responder in a simulated environment.

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