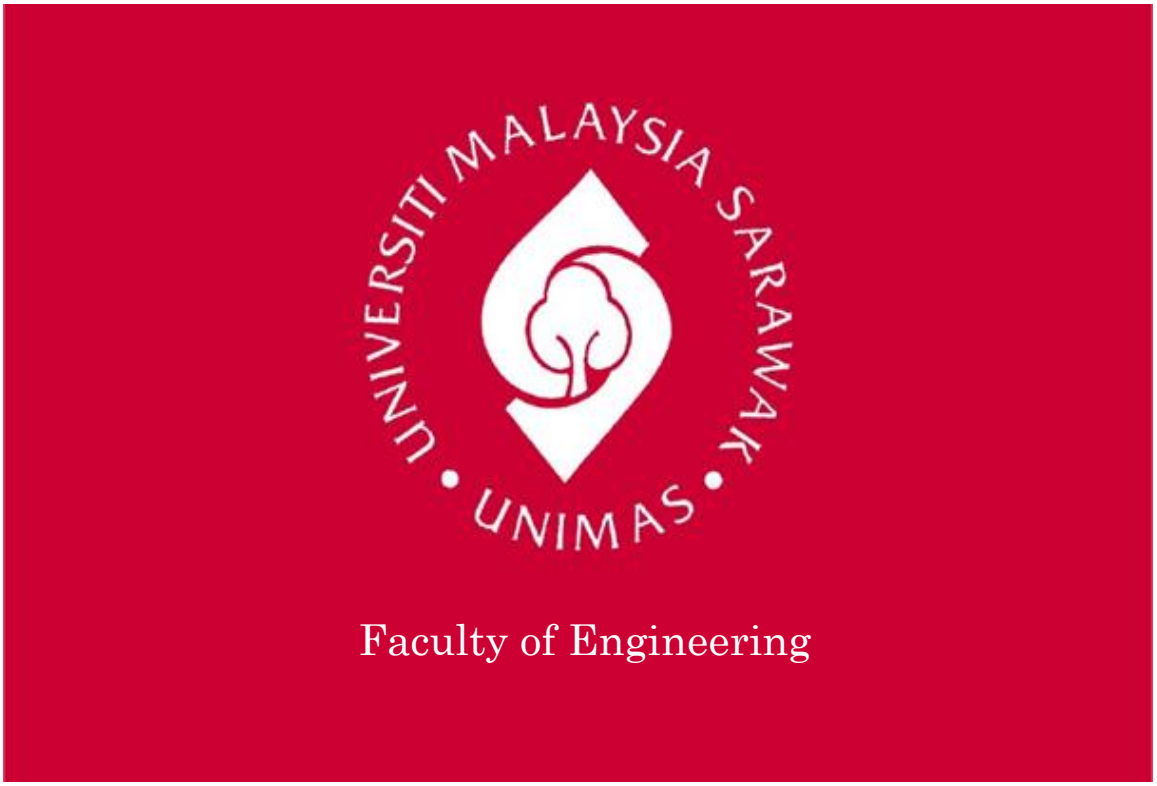

SAFETY HELMET FOR INDUSTRIAL APPLICATIONS DESIGN USING IOT

Jeffrey Ting Pik Lung

Bachelor of Engineering

Electrical and Electronics Engineering with Honours

2023

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report [√]
Masters [ ]
PhD [ ]

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SAFETY HELMET FOR INDUSTRIAL APPLICATIONS DESIGN USING IOT

Safety Helemt for Industrial Applications Design Using IOT

JEFFREY TING PIK LUNG

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering
Electrical and Electronics Engineering with Honours

Faculty of Engineering
Universiti Malaysia Sarawak

2023

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ABSTRACT

A safety helmet, often referred to as a hard hat, is a protective headgear designed to safeguard the wearer's head against potential hazards in various work environments and recreational activities. It is typically made of a hard, durable material, such as high-density polyethylene (HDPE) or polycarbonate, to provide impact resistance and protect the head from falling objects, debris, electrical shocks, and other potential dangers. The integration of Internet of Things (IoT) technology into safety helmets has introduced significant advancements in workplace safety and overall user experience. IoT-enabled safety helmets leverage sensors, connectivity, and data processing capabilities to enhance the functionality and effectiveness of traditional safety helmets. This project describes on the design and implementation of smart safety helmet system which can helps to alert the workers to reduce sunburn and heat-related illness at the construction site. This control system is based on three different sensors which include the UV sensor, temperature-humidity sensor, and body temperature sensor. Arduino Uno board acts as the main control unit and ESP8266 Wi-Fi module as a communication protocol. The workers can monitor the health and surrounding condition through the smart safety helmet systems easily. The system is easily controlled and can be monitored via user-friendly interface for smartphones. IoT based safety helmet system is applicable in this project, whereby the system can be monitored through mobile phones with Internet connections. Besides, an addition feature that alarm and alert the workers on the dangerous health and surrounding conditions enhance the protection to the workers is added to the system. Mobile applications such as ThingView are installed in the mobile phones to allow the workers to monitor the parameters from time to time. The main advantage of this smart safety helmet system is that it is a sensible, secure and easily configurable system that provides the workers a safer working environment at the construction area. Thus, all the objectives are achieved.

ABSTRAK

Topi keledar keselamatan, sering dirujuk sebagai topi keras, ialah penutup kepala pelindung yang direka untuk melindungi kepala pemakai daripada potensi bahaya dalam pelbagai persekitaran kerja dan aktiviti rekreasi. Ia biasanya diperbuat daripada bahan yang keras dan tahan lama, seperti polietilena berketumpatan tinggi (HDPE) atau polikarbonat, untuk memberikan rintangan hentaman dan melindungi kepala daripada objek jatuh, serpihan, renjatan elektrik dan potensi bahaya lain. Penyepaduan teknologi Internet of Things (IoT) ke dalam topi keledar keselamatan telah memperkenalkan kemajuan ketara dalam keselamatan tempat kerja dan keseluruhan pengalaman pengguna. Topi keledar keselamatan yang didayakan IoT memanfaatkan penderia, ketersambungan dan keupayaan pemprosesan data untuk meningkatkan fungsi dan keberkesanan topi keledar keselamatan tradisional. Projek ini menerangkan tentang reka bentuk dan pelaksanaan sistem topi keledar keselamatan pintar yang boleh membantu memberi amaran kepada pekerja untuk mengurangkan selaran matahari dan penyakit berkaitan haba di tapak pembinaan. Sistem kawalan ini berdasarkan tiga penderia berbeza yang termasuk penderia UV, penderia suhu-kelembapan dan penderia suhu badan. Papan Arduino Uno bertindak sebagai unit kawalan utama dan modul Wi-Fi ESP8266 sebagai protokol komunikasi. Pekerja boleh memantau kesihatan dan keadaan sekeliling melalui sistem topi keledar keselamatan pintar dengan mudah. Sistem ini dikawal dengan mudah dan boleh dipantau melalui antara muka mesra pengguna untuk telefon pintar. Sistem topi keledar keselamatan berasaskan IoT boleh digunakan dalam projek ini, di mana sistem boleh dipantau melalui telefon mudah alih dengan sambungan Internet. Selain itu, ciri tambahan yang membimbangkan dan memberi amaran kepada pekerja tentang kesihatan berbahaya dan keadaan sekeliling meningkatkan perlindungan kepada pekerja ditambahkan pada sistem. Aplikasi mudah alih seperti ThingView dipasang dalam telefon mudah alih untuk membolehkan pekerja memantau parameter dari semasa ke semasa. Kelebihan utama sistem topi keledar keselamatan pintar ini ialah ia adalah sistem yang waras, selamat dan mudah dikonfigurasikan yang memberikan pekerja persekitaran kerja yang lebih selamat di kawasan pembinaan. Dengan itu, semua objektif tercapai.

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BLE	Bluetooth Low Energy
DOSM	Department of Statistics Malaysia
GSM	Global System for Mobile Communications
HRI	Heat-Related Illness
IoT	Internet of Things
IIOT	Industrial Internet of Things
IDE	Integrated Development Environment
MATLAB	Matrix Laboratory
M2M	Machine to Machine
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
RFID	Radio-Frequency Identification
SD	Secure Digital
USB	Universal Serial Bus
UV	Ultraviolet
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Background

Safety is paramount in protecting individuals and property from harm or damage, and IoT offers innovative solutions to enhance safety measures. In industrial settings, IoT can monitor and control equipment and machinery, enabling real-time data collection on factors such as machine performance, environmental conditions, and worker safety. By analyzing this data, potential hazards can be identified, and preventive measures can be implemented promptly. IoT-based safety systems can automatically detect unsafe conditions, trigger alarms, or even shut down operations to prevent accidents and injuries. This proactive approach to safety significantly improves workplace safety standards, reduces the risk of accidents, and fosters a safer working environment.

On the other hand, health is a vital aspect of overall well-being, and IoT technologies can play a transformative role in this domain. Wearable technology refers to a category of electronic devices and accessories that can be worn on the body or incorporated into clothing and accessories. These devices are designed to integrate seamlessly into everyday life, providing functionalities that range from health and fitness tracking to communication, entertainment, and beyond. With advancements in miniaturization, sensor technology, and wireless connectivity, wearable devices have become increasingly popular and have gained significant attention in recent years. Wearable devices equipped with IoT capabilities, such as fitness trackers and health monitors, can collect data on vital signs, physical activity, sleep patterns, and more. This real-time data enables individuals to monitor their health, identify trends, and make informed decisions regarding their well-being. Moreover, IoT-enabled wearable devices can facilitate remote patient monitoring, particularly for individuals with chronic conditions. Healthcare professionals can access real-time data on patients' health status, enabling them to provide timely interventions and personalized care. IoT also has the potential to enhance preventive healthcare by leveraging data analytics to identify potential health risks and promote early interventions.

Furthermore, IoT-based solutions can contribute to emergency response and disaster management. Connected devices and sensors can monitor environmental conditions, detect potential hazards, and send alerts in case of emergencies. This enables faster response times and more efficient deployment of resources, ultimately saving lives and minimizing damage. However, it is essential to address privacy and security concerns associated with IoT deployments in safety and health applications. Ensuring the protection of sensitive personal data and implementing robust security measures are critical considerations to build trust and maintain the integrity of these systems.

1.2 Internet of Things (IoT)

The Internet of Things (IoT) comprises a system of tangible objects, including furniture, vehicles, structures, etc., that is linked to the internet and fitted with sensors, software, electronics, and circuitry to collect and exchange information. Using existing network infrastructure, IoT makes it possible for the remote sensing and control of items, enhancing efficiency and accuracy and enabling a more direct incorporation of the physical world with computer-based systems[1]. The term IoT pertains to the interconnection of physical devices, objects, or "things" that are equipped with sensors, software, and other technologies to gather and share data via the internet. These objects encompass a wide range, from common items like household appliances and wearables to industrial machinery and infrastructure.

The primary purpose of IoT is to enable communication and data exchange between these objects, allowing them to be remotely monitored, controlled, and automated. By connecting physical objects to the internet and integrating them with computer systems, IoT enables the seamless integration of the physical world with digital systems, leading to enhanced efficiency, improved decision-making, and the development of new applications and services.

Back in 1982, a specially modified vending machine at Carnegie Mellon University became the inaugural internet-connected application. It had the capability to track its inventory and determine the temperature of its beverages. Then, in 1999, a notable British innovator born in 1968 coined the phrase "Internet of Things" to illustrate the interconnectedness of the internet and the physical realm through pervasive sensors [1] [2].

IoT may function without the intervention of humans. In the industries of healthcare, transportation, and automotive, some prototypes of IoT applications have

been developed. Despite the fact that IoT technologies are still in their infancy, some important improvements in the integration of things equipped with sensors on the Internet have been made. Infrastructure, connection, interfaces, protocols, and standards are key hurdles in the development of IoT [1].

1.2.1 Industrial Internet of Things (IIoT)

IoT is an architecture that covers professional and personal connections between items and users. Its development is also causing significant changes in the industrial production environmentIndustrial IoT (IIoT) refers to the extension and implementation of IoT in the industrial domain. IIoT, alternatively recognized as the industrial internet or Industry 4.0, harnesses intelligent sensors and actuators to optimize manufacturing and industrial operations. It has allowed businesses to digitalize operations, enhance performance, and boost production [3].

The IIoT centers around the connectivity between machines, leveraging M2M communication, big data, and machine learning. This enables industries and enterprises to enhance operational efficiency and reliability. The IIoT encompasses various industrial applications, including robotics, medical devices, and software-driven manufacturing workflows [4]. In both circumstances, the benefits translate into time and resource savings. There is no need for human intervention, and manufacturing continues uninterrupted [3]. IIoT maximizes data from "dumb machines" through smart devices and real-time analytics. Smart machines excel in acquiring, interpreting, and transmitting critical information, facilitating faster and more accurate business decisions. Connected sensors and actuators swiftly identify inefficiencies and save time and money while supporting business intelligence initiatives.

IoT has enormous promise in manufacturing for quality standards, environmentally friendly and sustainable techniques, traceability of the supply chain, and overall productivity of the supply chain. IIoT plays a vital role in industrial settings, enabling predictive maintenance, enhanced field service, efficient energy management, and effective asset monitoring. With the rise of IoT, IoT network systems can considerably enhance workplace safety by monitoring environmental and physiological parameters [5].

There were 32,674 incidents of workplace accidents, including 312 occurrences of occupational deaths in Malaysia in 2020. The construction industry contributes to 81

instances of occupational fatalities, ranking third among all industries as shown in Figure 1.1 [6].

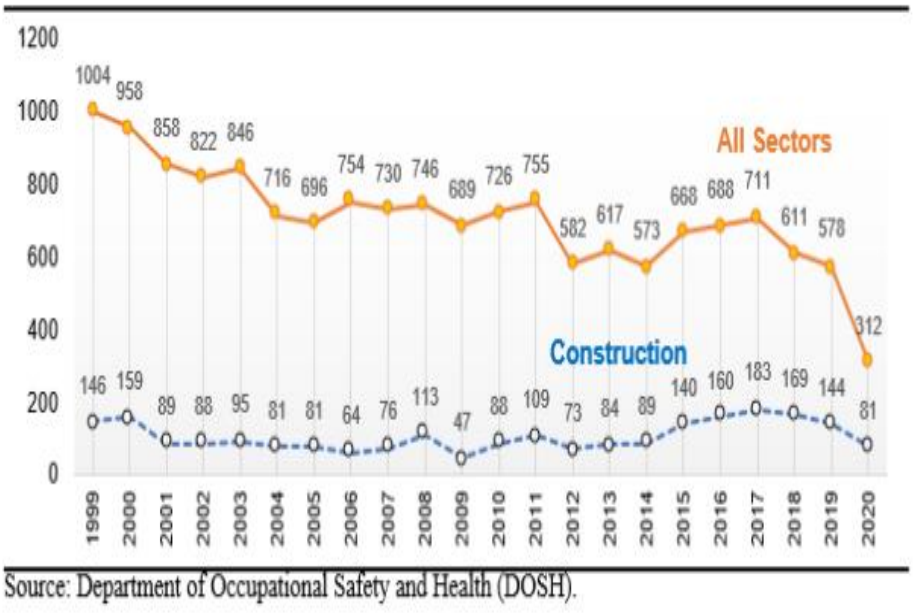

Figure 1.1: Occupational Fatalities for Construction and All Sectors [6]

This industry continues to be the most dangerous, rather than exhibiting a long-term steady trend, as it has the highest occupational death rate, which is 3.3 times greater than the entire national occupational fatalities in 2020, as shown in Figure 1.2 [6].

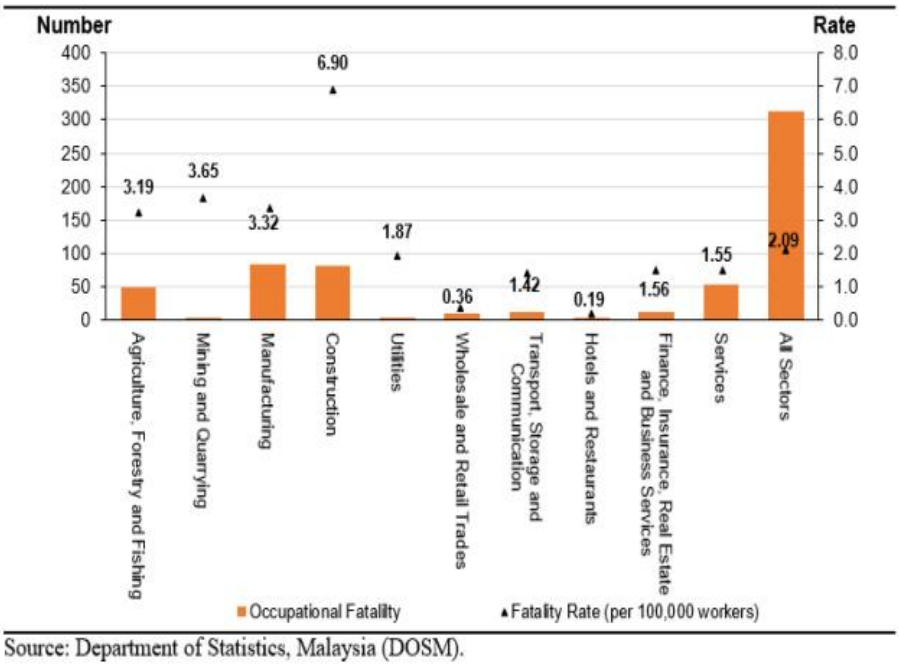

Figure 1.2: Occupational Fatalities and Fatality Rate[6]

Workers are frequently exposed to various outdoor elements during work. Outdoor workers who are exposed to high temperatures and labor in the searing sun for extended periods are in danger of sunstroke, sunburn, heat exhaustion, headache, fever, weariness, and skin cancer [7].

In terms of occupational HRI, the construction sector is the most dangerous. According to US. NIOSH [8], the construction sector has had the greatest number of HRI-related fatalities for a long time [9]. Since 2010, over 500 individuals have died because of heat-related illness (HRI), with 20 dying during Japan's extremely hot summer [10]. According to the Japanese Ministry of Health, Labour, and Welfare, in 2018, there is around 40% of heat-related illnesses occurred in the construction business. According to the WHO, "any deterioration in a worker's daily activity performance owing to the heat, cold, or harsh weather shall be considered a 'health consequence' of climatic conditions."

1.3 Problem Statement

Safety helmets (commonly known as hard hats) can help avoid harm in an uncontrolled environment. A helmet can help to avoid or reduce head and brain injuries. Hard hats are a crucial and mandatory requirement in almost all construction sites and manual labor environments. The most common and fundamental form of personal protective equipment (PPE) is industrial safety helmets. Wearing a helmet minimizes the chances of critical brain damage and death of workers as the helmet absorbs most of the impact during a collision, rather than the head of the wearers. Nevertheless, wearing the correct helmet is as crucial as wearing a helmet.

Workers exposed to high temperatures and the sun for extended periods, on the other hand, are in danger of sunstroke, sunburn, heat cramps, and a variety of heat-related illnesses.

Sunstroke or heatstroke is more prevalent when performing strenuous physical labor. Less study is being undertaken on the IIoT system for the enhancement of industrial items, with less emphasis on construction sectors (safety helmets). Construction workers, for example, frequently become ill because of a lack of knowledge of environmental and physiological situations.

Thus, heat and UV indicators are key variables to consider while designing a safety helmet. It will measure the UV index and heat index. To address these issues, our project is developing a smart safety helmet system. A smart safety helmet system that

monitors environmental and physiological factors can significantly enhance worker safety. When hazardous situations are recognized, workers are alerted and warned.

1.4 Objectives

This project aims to develop and design a smart safety helmet with wearable sensors based on the IoT to measure environmental and physiological conditions. The following must be accomplished to achieve the objective:

- To investigate different sensors in the IoT industry focusing on industrial areas.
- To design smart safety helmet that is used in construction areas.
- To analyse the performance of the proposed smart safety helmet with current research.

1.5 Project Scope

The project is divided into two main parts which are software development and hardware development. The project will proceed according to the following steps:

(i) Modelling and simulation

− The control algorithm is simulated using C++ language on the Arduino Uno

(ii) Hardware implementation

− Design and implementation of the smart safety helmet prototype using Arduino Uno as the main control unit.

(iii) Overall testing of the developed system

− To determine the efficiency of the system for smart safety helmet applications.

− To identify the UV Index and Heat Index under the sun at outdoor condition during daytime.

1.6 Report Organisation

This report consists of five chapters from introduction, literature reviews, methodology, results, and discussion, as well as conclusion and recommendations. In chapter 1, the project's background, current construction area issues, objectives, and project outlines are all covered. The objectives of this project explain the goal.

The background study related to IoT safety and health application as to propose wearable sensor network system is presented in Chapter 2. It reviews the current techniques for developing wearable sensor network system, the various methods that have

been employed with the implement of IoT, as well as the findings from earlier studies based on publications in journals, articles, and conference papers.

The approach taken in this project is covered in Chapter 3. It explains the steps taken for the developing of smart safety helmet system, and a flowchart showing the project's workflow is included.

Chapter 4 presents the findings of a simulation, where the proposed approach is used on a test dataset and the outcomes are recorded. The project and its outcomes are outlined in Chapter 5.

This project's future recommendations and enhancements are also being discussed.

1.7 Summary

In this chapter, it explains on smart safety helmets technology can be equipped with sensors that measure the ultraviolet (UV) index and heat index at a worksite. UV index measures the sun's UV radiation strength and helps assess the risk of sunburn and other related health effects. A high UV index indicates a greater risk of harmful UV radiation, and workers may be advised to take additional precautions, such as wearing protective clothing or applying sunscreen.

The heat index, also known as the "feels like" temperature, is a measure of how hot it feels when the effects of humidity and wind speed are considered. A high heat index can be dangerous, as it can lead to heat stroke and other heat-related illnesses. By measuring the heat index, smart safety helmet systems can alert workers to the risk of heat-related health issues and advise them to take appropriate precautions, such as drinking plenty of water and seeking shade. Besides, health conditions of the workers also consider. Thus, body temperature also includes in the smart safety helmet design. Body temperature is an important vital sign that can indicate the presence of illness or infection. By integrating temperature sensors into a smart safety helmet, it becomes possible to continuously monitor the workers' body temperature. Abnormal temperature readings can alert the wearer or a supervisor to potential health issues, allowing for early intervention and preventing the spread of contagious diseases in certain environments.

In certain industries or working conditions, such as construction, mining, or firefighting, workers are exposed to high temperatures and heat stress. Monitoring body temperature can help identify individuals at risk of heat-related illnesses, such as heat exhaustion or heatstroke. The smart helmet can provide real-time alerts or notifications

to workers or supervisors when body temperature exceeds safe limits, allowing for immediate action to be taken, such as rest breaks or medical assistance.

Overall, the inclusion of UV index, heat index, and body temperature measurements in smart safety helmet systems can help improve the safety of workers by providing them with real-time information about the hazards present at their worksite. This can help them make informed decisions about how to protect themselves from the sun and heat, and can help reduce the risk of sunburn, heat stroke, and other heat-related illnesses.