Universiti Teknologi MARA
Cawangan Perak

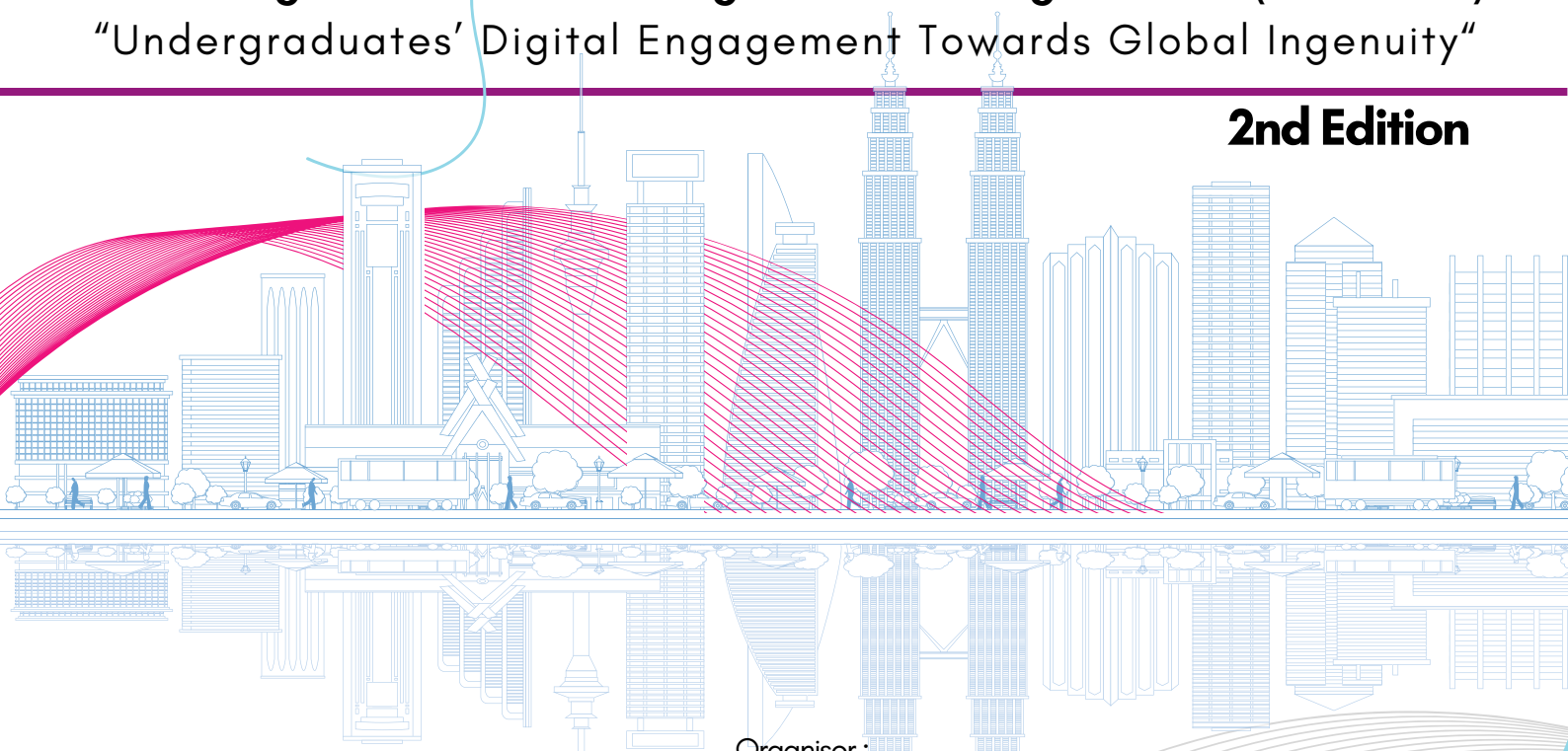
e - Proceedings

IUGeT

Proceeding for International Undergraduates Get Together 2024 (IUGeT 2024)

"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition



Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

Bauchemic (Malaysia) Sdn Bhd

Universitas Sebelas Maret

Universitas Tridinanti (UNANTI)

Publication date :

November 2024

e - Proceedings

Proceeding for International Undergraduates Get Together 2024 (IUGeT 2024)

"Undergraduates' Digital Engagement Towards Global Ingenuity"

Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

Bauchemic (Malaysia) Sdn Bhd

Universitas Sebelas Maret

Universitas Tridinanti (UNANTI)

© Unit Penerbitan UiTM Perak, 2024

All rights reserved. No part of this publication may be reproduced, copied, stored in any retrieval system or transmitted in any form or by any means; electronic, mechanical, photocopying, recording or otherwise; without permission on writing from the director of Unit Penerbitan UiTM Perak, Universiti Teknologi MARA, Perak Branch, 32610 Seri Iskandar Perak, Malaysia.

Perpustakaan Negara Malaysia Cataloguing in Publication Data

No e- ISBN: 978-967-2776-42-0

Cover Design: Muhammad Anas Othman
Typesetting : Arial

e-ISBN: 978-967-2776-42-0

iVUTI 2024 Committee

Project Leader
Ts Muhammad Naim Mahyuddin

Assistant Project Leader 1
Dr Ezzat Fahmi Ahmad

Assistant Project Leader 2
En Mohd Fadzli Mustaffa

Secretariat 1
Syahmimi Ayuni Ramli

Secretariat 2
Nur Afiqah Anuar

Treasurer
Dr Izrahayu Che Hashim

Registration Team
Dr Asmaa' Che Kassim
Dr Fatin Syazwina Abdul Shukor
Dr Suwaibatul Islamiah Abdullah Sani

Certification Team
Ts Nurul Huda Abdul Hadi
Ir Raja Nurulhaiza Raja Nhari
Dr Siti Jamiah Tun Jamil

Graphic Team
Mohammad Fitry Md Wadzir
Jannatun Naemah Ismam,
Nor Azizah Talkis
Wan Nur Hanani Wan Abdullah

Promotion Team
Nurulanis Ahmad@Mohamed
Najma Azman
Ts Sr Dr Asmat Ismail

Evaluation Team
Dr Suzanah Abdullah
Haslina Hashim
Azlizan Adila Mohamad
Noorsazwan Ahmad Pugi
Gs Dr Munirah Radin Mohd Mohktar
Mohd Najib Husain

Publication Team
Nur'Ain Ismail (Head)
Siti Nurhayati Hussin (Chief)
Dr Nuramira Anuar (Sub-chief)
Dr Paul Gnanaselvam A/L Pakirnathan
Noorlinda Alang
Norasyikin Abdul Malik
Halimatussaadiah Iksan
Nurdiyana Mohamad Yusof
Syaza Kamarudin
Dr Wan Nordiana Wan Ali
Dr Ida Nianti Mohd Zin
Dr Nurul Sahida Fauzi
Dr Noor Rizallinda Mohd Ishak
Dr Lizawati Abdullah
Iza Faradiba Mohd Patel
Nurfatima Wahida Nasir
Nazirul Mubin Mohd Noor

Proceeding for International Undergraduates Get Together 2024 (IUGeT 2024)
Undergraduates' Digital Engagement Towards Global Ingenuity
e-ISBN: 978-967-2776-42-0

SAFETY HELMET CONSTRUCTION

Muhammad Alif Azanizam[1*], Raziq Iskandar[2], Adam Iskandar[3], and Naqib Zahir[4]

[1,2,3,4]Department of Built Environment Studies and Technology, College of Built Environment, Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus 32610 Seri Iskandar, Perak

*muhammadalif0520@gmail.com

Abstract
Safety helmets are crucial for protecting construction workers from head injuries. Recent innovations focus on improving safety, comfort, and functionality. Advances in materials like high-density polyethylene (HDPE) and acrylonitrile butadiene styrene (ABS) have led to helmets that are both durable and lightweight. Improved suspension systems with better shock absorption and adjustable straps ensure a secure fit, reducing the risk of injury. Smart technologies have been integrated into modern helmets, including sensors that detect impacts, monitor environmental conditions, and track the wearer's location. These helmets can send alerts in emergencies, enhancing site safety. Some models also feature built-in communication systems, allowing workers to stay connected hands-free. Enhanced visibility is another key area, with high-visibility colours, reflective strips, and LED lights improving worker safety in low-light conditions. Comfort improvements include better ventilation, sweat-wicking liners, and adjustable padding for a customised fit. Sustainability is also a focus, with the use of recycled materials and eco-friendly manufacturing processes. These innovations in helmet design significantly improve protection, comfort, and environmental impact in the construction industry.

Keywords: *safety helmet, smart technologies, HDPE and ABS*

1. INTRODUCTION

In an era where technology is transforming every aspect of our lives, the evolution of safety equipment in industrial and hazardous work environments is no exception. The emergence of smart safety helmets represents a revolutionary advance in workplace safety practices. These helmets are not just protective gear; they are equipped with advanced sensors and communication technologies that redefine how we safeguard workers in high-risk settings. Smart safety helmets integrate a range of sophisticated features designed to monitor environmental conditions, track worker location in real-time, and even assess the physiological state of the wearer. By providing immediate alerts, facilitating seamless communication, and enabling proactive safety measures, these helmets aim to mitigate risks, enhance operational efficiency, and ultimately ensure the well-being of every worker. This introduction sets the stage for exploring the transformative impact of smart safety helmets, highlighting their role in fostering safer workplaces and ushering in a new era of occupational safety standards. As industries increasingly prioritise employee welfare and technological innovation, the adoption of smart safety helmets emerges as a pivotal strategy in achieving these goals effectively and sustainably.

2. MATERIALS AND METHODS

2.1 Features

Several features are used in the manufacturing of safety helmets:

i. Helmet
- Type: Standard industrial safety helmet
- Material: High-density polyethylene (HDPE) or fibreglass
- Specifications: Meets ANSI Z89.1-2014 Type I, Class G, and E standards

e-ISBN: 978-967-2776-42-0

ii. Sensors

a) Accelerometer:
- Model: ADXL345
- Range: ±16 g
- Interface: I2C/SPI digital interface

b) Gyroscope:
- Model: MPU-6050
- Range: ±250, ±500, ±1000, ±2000 °/s
- Interface: I2C

c) Temperature Sensor:
- Model: DS18B20
- Range: -55°C to +125°C
- Interface: 1-Wire digital interface

d) Gas Sensor:
- Model: MQ-2
- Detection Range: 200-10000 ppm for gases like LPG, smoke, methane, etc.

e) Proximity Sensor:
- Model: HC-SR04 ultrasonic sensor
- Range: 2 cm to 400 cm
- Interface: Digital

iii. Microcontroller
- Model: Arduino Uno or ESP32
- Specifications: 32-bit processor, Wi-Fi and Bluetooth (for ESP32), multiple GPIO pins

iv. Power Supply
- Type: Rechargeable lithium-ion battery
- Specifications: 3.7V, 2000mAh

v. Communication Module
- Type: Bluetooth module (HC-05) or Wi-Fi module (ESP8266)
- Specifications: Serial communication interface

vi. Other Components
- PCB: Custom-designed PCB for integrating all components
- Casing: Waterproof and shockproof casing to protect electronic components
- Connectors and Wires: For establishing connections between sensors and the microcontroller

2.2 Methods

The manufacturing process involves the following:

i. Design and Integration
- Helmet Modification: Modify the helmet to integrate sensor mounts without compromising structural integrity.
- Sensor Placement: Determine optimal locations for each sensor to ensure accurate data collection (e.g., accelerometer and gyroscope at the helmet centre, gas sensor at the front).
- Circuit Design: Design the circuit schematic using software like Eagle or KiCad to integrate all sensors with the microcontroller.
- PCB Fabrication: Manufacture the custom PCB based on the designed schematic.

ii. Assembly
- Component Soldering: Solder all sensors and the microcontroller onto the PCB.
- Wiring: Connect sensors to the microcontroller using appropriate connectors and wires.

e-ISBN: 978-967-2776-42-0

- Encapsulation: Place the assembled PCB and battery inside the waterproof casing.
- Mounting: Secure the casing and sensors onto the helmet.

iii. Software Development

- Firmware Development: Write and upload the firmware to the microcontroller to read sensor data, process it, and communicate with the external device via Bluetooth or Wi-Fi.
- Calibration: Calibrate sensors to ensure accurate readings, including setting initial reference values and compensation algorithms.
- Data Processing: Implement algorithms for real-time data processing and alert generation based on predefined safety thresholds.
- Communication Protocol: Develop the protocol for data transmission to a remote monitoring system or mobile application.

iv. Testing

- Bench Testing: Perform initial testing on a workbench to validate the functionality of each sensor and the overall system.
- Field Testing: Conduct tests in real working environments to assess performance under actual conditions.
- Data Analysis: Collect and analyse data to verify the accuracy and reliability of the sensor readings.
- Iterative Improvement: Make necessary adjustments based on test results to improve system performance and reliability.

v. Safety and Compliance

- Safety Check: Ensure all electrical components are safely enclosed and insulated to prevent electrical hazards.
- Standards Compliance: Verify that the helmet and integrated system comply with relevant safety standards and regulations.

2.3 Materials

Several materials are used in the manufacturing of safety helmets:

i. Shell materials

- Absorbing and Distributing Impact Forces: The primary purpose of the shell is to absorb and distribute the forces from an impact over a larger area, reducing the intensity of the force on the wearer's head.
- Materials like polycarbonate, HDPE, and ABS are chosen for their high impact resistance, meaning they can withstand significant force without cracking or breaking.
- Penetration Resistance: The shell is able to resist penetration from sharp or falling objects. Materials such as fibreglass and Kevlar composites are exceptionally good at preventing objects from piercing through the helmet.

ii. Straps

- Securing the Helmet: Ropes or straps, particularly the chinstrap, secure the helmet firmly on the wearer's head, preventing it from slipping or falling off during use. Adjustable straps ensure a snug fit, accommodating different head sizes and shapes.
- Shock Absorption: The suspension system, often consisting of woven straps or webbing, helps to absorb and dissipate impact forces. This system spreads the force over a larger area, reducing the impact on the wearer's head.
- Enhanced Comfort: Ropes or straps help to distribute the weight of the helmet evenly across the head, enhancing comfort for prolonged use.
- Padding attached to the straps can reduce pressure points and prevent discomfort.

e-ISBN: 978-967-2776-42-0

iii. Sensors

- Impact Monitoring: Sensors can detect and measure the force of impacts on the helmet, providing valuable data in the event of an accident. This information can help determine the severity of the impact and whether medical attention is required.
- Vital Signs Monitoring: Some helmets are equipped with sensors that monitor the wearer's vital signs, such as heart rate, body temperature, and respiratory rate. This is particularly useful in high-risk environments where the physical condition of the worker needs to be continuously monitored.
- GPS and Proximity Sensors: GPS sensors can track the location of workers, which is essential in large industrial sites or remote areas. Proximity sensors can prevent collisions by alerting workers when they are too close to machinery or other hazards.

Table 1. Type of Materials

Straps	Helmet shell material	Sensor

3. RESULTS AND DISCUSSION

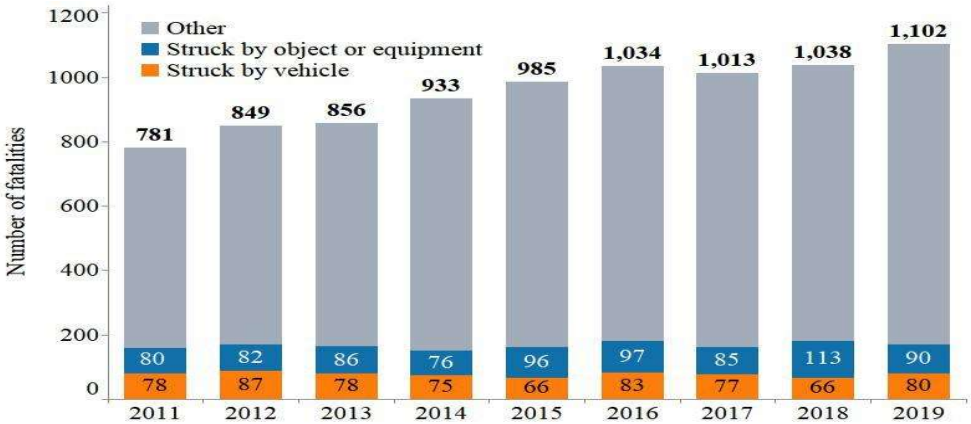


Figure 1. Construction Fatalities Statistics
(Source: Construction Fatalities Statistics for 2019-2011)

In 2011, there were 781 construction-related fatalities, including 78 caused by vehicle collisions, 80 by being hit by objects or equipment, and 623 for other reasons. The death toll rose to 849 in 2012, with 87 people struck by vehicles, 82 hit by objects or equipment, and 680 fatalities due to other causes. In 2013, construction deaths increased to 856, with 78 caused by vehicle collisions, 86 by objects or equipment, and 692 from other causes. By 2014, the number of deaths further increased to 933, including 75 from vehicle strikes, 76 from being hit by objects or equipment, and 782 from other causes.

e-ISBN: 978-967-2776-42-0

In 2015, there were 982 fatalities in the construction industry, with 66 due to vehicle collisions, 96 from being hit by objects or equipment, and 820 from other causes. In 2016, the death toll rose to 1,034, with 83 deaths caused by vehicles, 97 by objects or equipment, and 854 by other factors. In 2017, construction-related deaths totalled 1,013, with 77 individuals struck by vehicles, 85 by objects or equipment, and 851 fatalities from other causes. In 2018, the number of construction deaths was 1,038, with 66 caused by vehicles, 113 by objects or equipment, and 859 by other reasons. In 2019, the fatalities increased to 1,102, including 80 vehicle collisions, 90 from objects or equipment, and 932 from other causes.

Factors leading to construction accidents involving safety helmets include the following:

i. Inadequate Use of Safety Helmets

- Non-compliance: Workers may not wear helmets consistently or correctly, reducing their effectiveness.
- Improper Fit: Helmets that do not fit properly can fail to protect the head adequately during an impact.
- Wear and Tear: Over time, helmets can degrade due to exposure to harsh conditions, reducing their protective capabilities.

ii. Helmet Limitations

- Impact Severity: Safety helmets are designed to protect against certain levels of impact. Extremely high-impact events, such as falling from significant heights or being struck by heavy objects, can exceed the protective capabilities of the helmet.
- Coverage: Helmets primarily protect the top and sides of the head. Injuries to the face, neck, or other parts of the head may still occur.

iii. Environmental and Operational Factors

- High-Risk Activities: Some construction activities inherently involve higher risks, such as working at heights or in areas with heavy machinery.
- Environmental Hazards: Conditions such as extreme weather, uneven terrain, and poor visibility can increase the likelihood of accidents.
- Human Error: Mistakes made by workers or supervisors, such as incorrect use of equipment or inadequate safety protocols, can lead to fatal incidents.

iv. Helmet Design and Technological Limitations

- Outdated Designs: Some helmets may not incorporate the latest materials or technologies that enhance protection.
- Lack of Advanced Features: Modern helmets can include features like built-in sensors to detect impacts, but older models may lack these enhancements.

4. CONCLUSION

The smart safety helmet stands at the forefront of modern workplace safety innovations, revolutionising how industries protect their workers. Equipped with advanced sensors and communication technologies, these helmets provide real-time monitoring of environmental conditions such as temperature, air quality, and hazardous gas levels. This constant monitoring ensures that workers are alerted promptly to any potential risks, allowing them to take preventive measures or evacuate if necessary.In addition to environmental monitoring and location tracking, some smart helmets also include biometric sensors to monitor the physiological condition of the wearer. This can detect signs of fatigue or stress, prompting timely breaks or intervention to prevent accidents caused by impaired physical or mental state. Furthermore, data collected by these helmets can be analysed to identify patterns of risk and improve safety protocols over time. This data-driven approach not only enhances individual safety but also contributes to the overall workplace safety culture and regulatory compliance.

e-ISBN: 978-967-2776-42-0

Overall, the smart safety helmet represents a significant advancement in occupational safety, leveraging technology to proactively protect workers, enhancing operational efficiency, and ultimately create safer and more productive work environments. As industries continue to embrace digital transformation, the adoption of smart safety helmets is expected to grow, ushering in a new era of workplace safety where accidents are minimised, and employee well-being takes centre stage.

5. REFERENCES

Derwing, Balqis Lim (February 25, 2019). Innovation Smart helmet for workers. 2024 © New Straits Times, New Straits Times Press (M) Bhd (Co. No. 196101000449 / 4485 H)

Derwing, TM Research & Development, (2000). Redefining Safety with Smart Helmets.

Derwing, Trends © 2024 TREND HUNTER Inc. Laura McQuarrie — November 23, 2023 — Tech. Smart Safety Helmets,

UNIVERSITI TEKNOLOGI MARA
Cawangan Perak

e - Proceedings

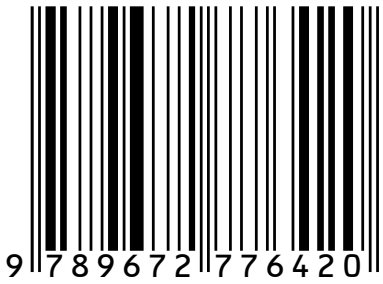
IUGeT

Proceeding for International Undergraduates Get Together 2024 (IUGeT 2024)

"Undergraduates' Digital Engagement Towards Global Ingenuity"

e-Proceeding IUGeT 2024 2nd Edition

e ISBN 978-967-2776-42-0



Unit Penerbitan UiTM Perak

(online)