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Safety Helmet with Collision Detection System

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Collision detection system, GPS module, ESP32 microcontroller, real-time display, safety helmet, google maps linked SMS

Abstract

A comprehensive smart helmet system integrating various sensors and communication modules has been developed for enhancing safety and functionality during motorcycle rides. The research addresses the critical issue of road safety for motorcyclists by introducing an accident detection system using accelerometers and gyroscopes, coupled with an emergency response system. The implementation utilizes an ESP32 microcontroller, MPU6050 sensor, GSM module, and GPS module. The findings showcase the effectiveness of the collision detection system and its potential to significantly improve emergency response times. The abstract underscores the importance of such technological interventions in reducing accident-related fatalities and injuries among motorcyclists. The discussion emphasizes the need for wider adoption of similar smart helmet systems and highlights the potential for future enhancements in both hardware and software components. The outcomes suggest a paradigm shift in motorcycle safety measures, urging policymakers and manufacturers to consider integrating these technologies into standard safety protocols.

1. Introduction

Motorcycle accidents pose a persistent and alarming challenge on a global scale, and Malaysia is no exception to this concerning trend. Over the past decade, statistical data has highlighted the consistently high number of motorcycle accidents in the country, resulting in numerous injuries and fatalities. Contributing factors such as reckless driving, inadequate road conditions, and a lack of comprehensive safety measures have exacerbated the issue. While conventional helmets are fundamental for rider protection, they often lack advanced features that could effectively mitigate risks and elevate overall safety standards [1]. In response to this critical scenario, there has been a growing acknowledgment of the potential of advanced technologies to address the challenges in motorcycle safety. The conventional and regular helmet, when integrated with a sophisticated technological system, emerges as a promising solution to enhance rider safety amidst these existing challenges [2]. To tackle this complex issue effectively, careful considerations must be made for the selection of hardware components, development of intricate software algorithms, and the creation of an intuitive user interface. These components collectively contribute to the creation of a user-friendly and highly effective technological solution that has the potential to revolutionize motorcycle safety and reduce the impact of accidents on the roads [3].

2. Material and Methods

Based on multiple related previous studies, this project's main purpose is to develop a helmet with a collision detection system when accident happens toward motorcyclist. All the corresponding materials have been set up to follow the requirements of this project to work. Additionally, the ESP32 microcontroller serves as the central processing unit, orchestrating the seamless integration of these components that are involved in this project. The overall methodology involves a systematic approach to hardware integration, coding, and testing.

2.1 Material

The primary components utilized in this project include the MPU6050 accelerometer and gyroscope for collision detection, the NEO-6M GPS module for real-time location monitoring, and the SIM800A GSM module for emergency response communication as listed in Table 1.

Table 1 *The list of components*

Project Components
ESP 32 Microcontroller
MPU6050 Accelerometer and Gyroscope Sensor
NEO 6M GPS Module
SIM800A GSM Module

2.2 Method

A comprehensive project plan and schedule lay the groundwork for the successful helmet safety with collision detection system. The project plan encompasses a workflow diagram, providing a visual representation of the project's processes.

2.3 Flowchart of the System

This diagram encapsulates the flow of processes and serves as a guide for the programmed code. Fig. 1 illustrates the workflow for the safety helmet with collision detection system:

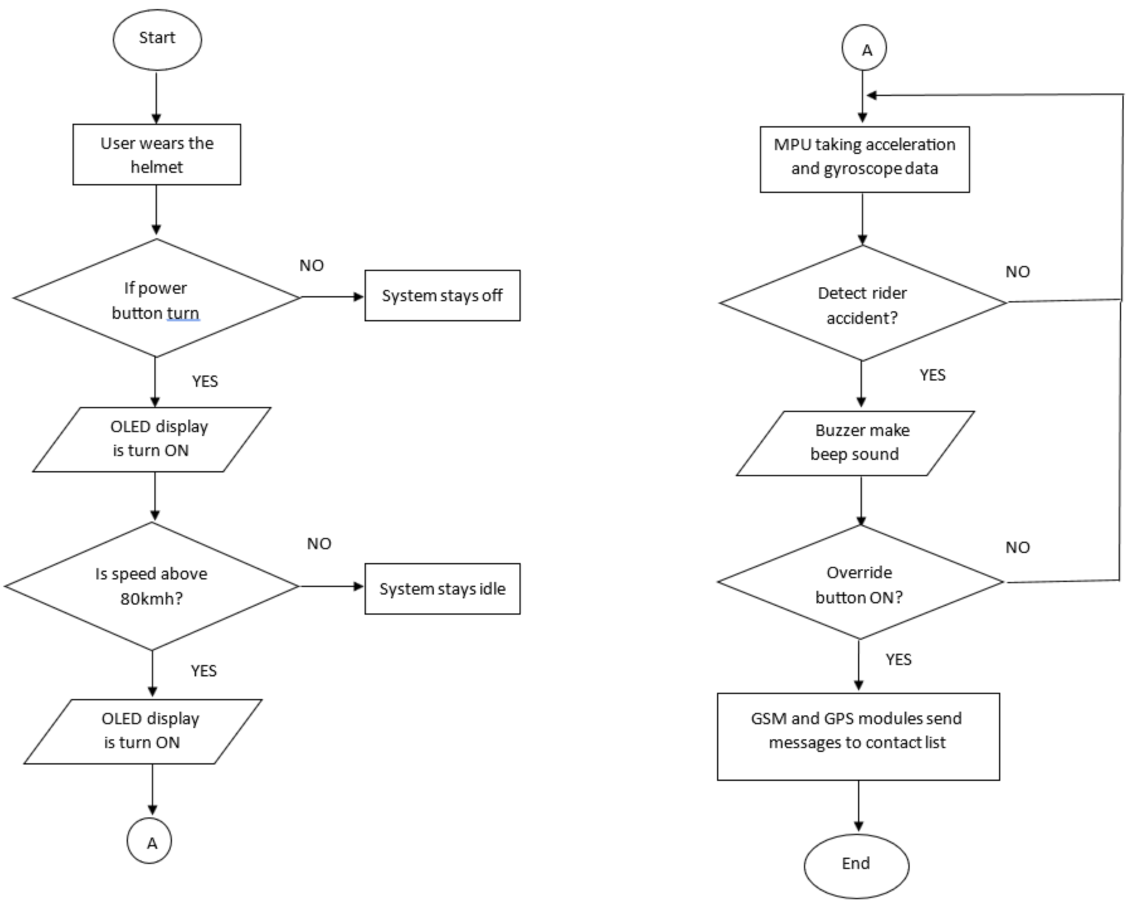

Fig. 1 *Flowchart of safety helmet with collision detection system*

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2.4 System Simulation Process

The Proteus programs were used to illustrate the circuit diagram of the whole system, monitor the input and output of the whole system in serial monitor and easy to spot any error in the coding for the system. Proteus offers real-time simulation capabilities. This allows designers to observe how different parts of a system interact in a real-time environment. This software also capable to prototype the whole hardware system before the hardware installation have been done. This is to ensure that there are not any errors that can possibly can be happen in the future. Fig. 2 shows the project circuit diagram.

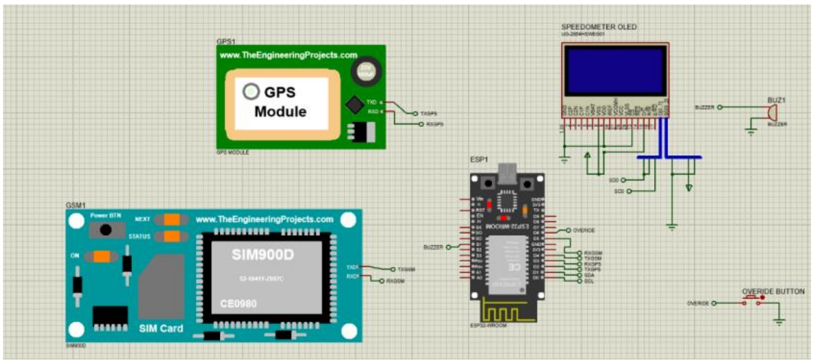


Fig. 2 *Circuit diagram of safety helmet with collision detection system*

2.5 Methodology Project Process

This project's methodology focuses on developing an advanced helmet system to enhance user safety and provide real-time information for motorcyclists. Beginning with a detailed requirement analysis, we selected the versatile ESP32 microcontroller as the central unit for seamless sensor communication [4]. For collision detection, accelerometers and gyroscopes were chosen, with the MPU6050 sensor considered initially. An override mechanism using a switch deactivates the system when needed. Communication involves a GSM module for wireless communication, and OLED displays show relevant information to the user [5]. Thorough testing and optimization ensure system functionality and user-friendliness. User feedback is crucial for refining the system and addressing any issues [6].

3. Result and Discussion

The primary objective of the data result to ensure that collision detection systems work in short of time of reaction to send the SMS location of the GPS module itself. The result obtained from number of trials of experiment based on data collected of collision detection system and transmission of GPS location of SMS.

3.1 Response Time for Emergency Response System During Accident Simulation

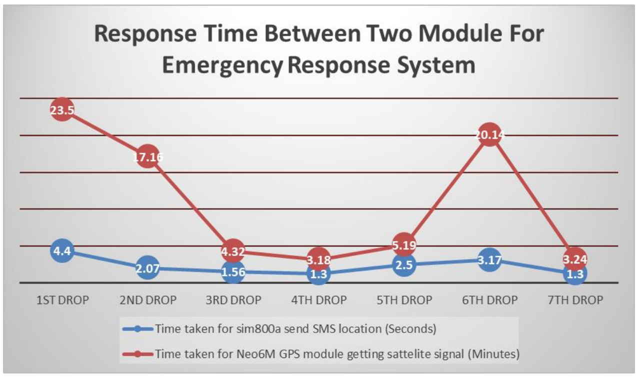
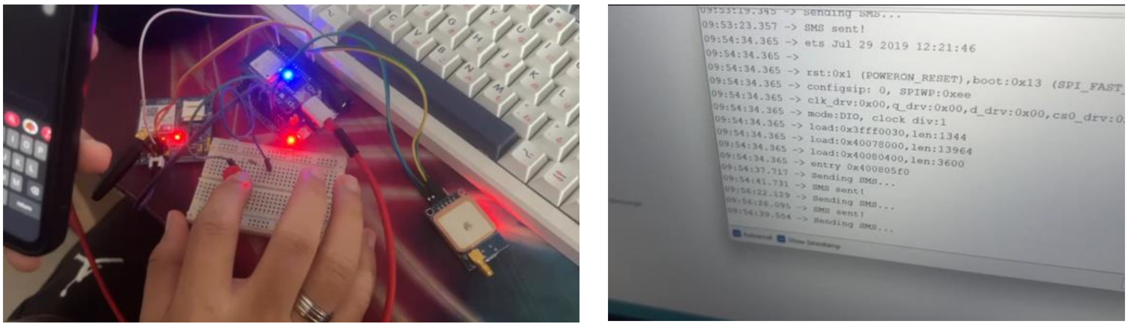


Fig. 3 *The response time have been recorded to find the effectiveness of emergency response system*



(a) **(b)**

Fig. 4 *Project experiment. (a) Triggering emergency response system by push a button for early experiment; (b) Process of sending SMS in serial monitor for early experiment*

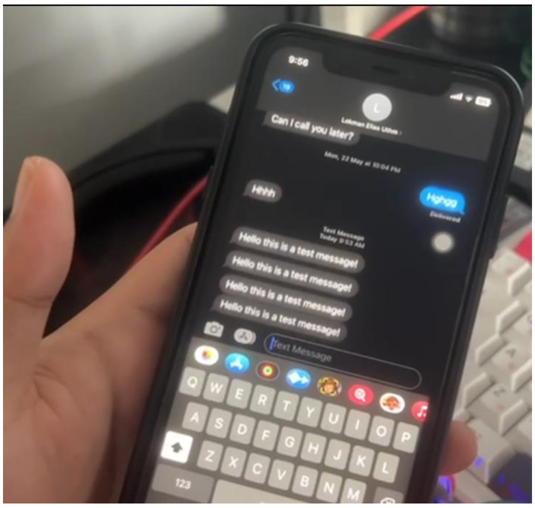


Fig. 5 *Succeed in receiving SMS for emergency response system*

Based on Fig. 3, the effectiveness of response time is crucial for obviously reason which is the system is engaged when accident happens. Swift location updates from the GPS module and timely communication via the GSM module can be vital for emergency response teams to help promptly. Besides that, it is also to be able to send the GPS location as soon as possible for real time location information. In terms of GSM communications, a good response time ensures reliable and timely data transmission. Delayed responses can lead to latency issues, affecting the overall performance of the system. As shown in Fig. 4 and Fig. 5 are the process to transmit the SMS to the registered number. In summary, a good response time for GPS and GSM modules is essential for applications that require real-time location information, emergency responsiveness, and reliable communication. It enhances the overall efficiency, accuracy, and effectiveness of systems relying on these modules.

3.2 Accelerometer and Gyroscope Data During Accident Simulation

The data has been monitored and collected for comparison. First, the axis Z on gyroscope value had to tested to find the optimum value to replicate the data that can been taken when the accident happened as shown in Fig. 6. Meanwhile, the helmet indicated the falling from the motorcycle at certain speed. To make this happen, the system had to been lifted to the height of motorcycle rider position from the ground, and the helmet was dropped to the floor several time. The helmet had to do several types of positioning when it dropped. The calibration test is shown in Fig. 7.

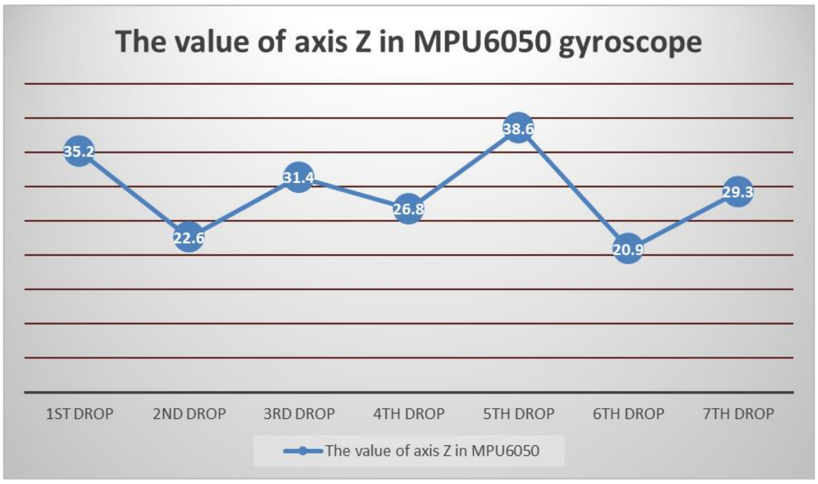
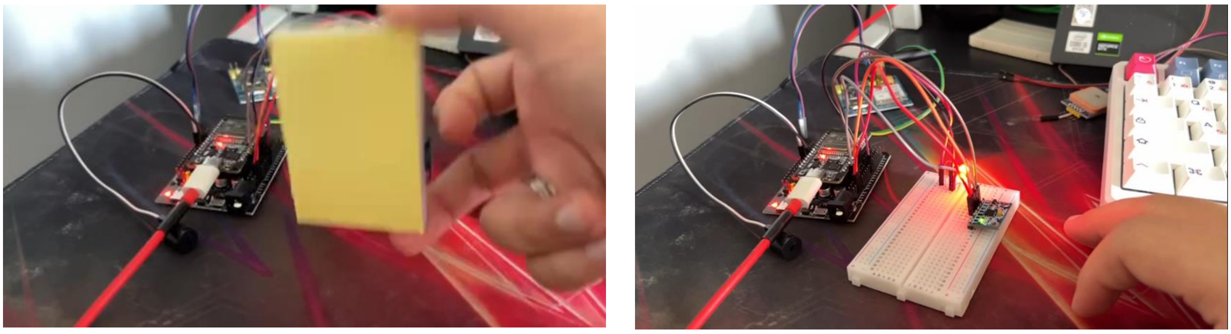


Fig. 6 *Axis Z in MPU6050 gyroscope data*



(a) (b)

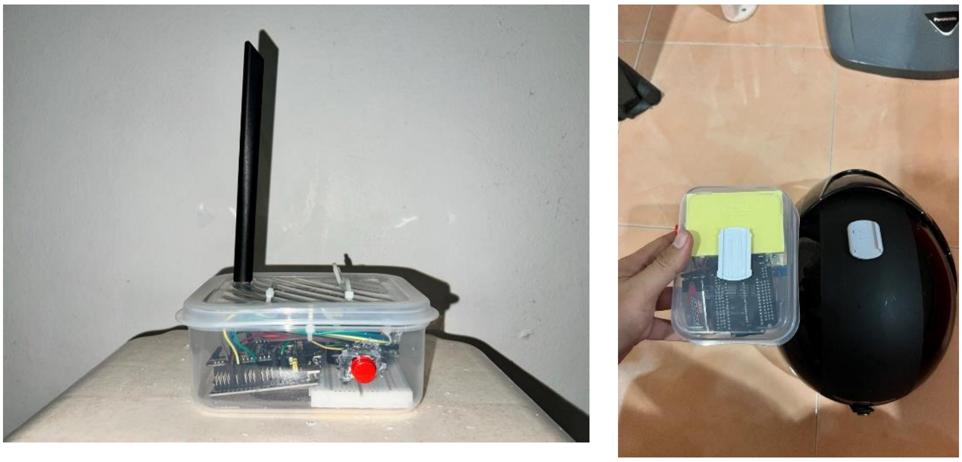
Fig. 7 *Early test of calibration to set up conditions for MPU6050*

3.3 Project Layout

A comprehensive project plan and schedule lay the groundwork for the successful helmet safety with collision detection system. The project plan encompasses a workflow diagram, providing a visual representation of the project's processes. The Fig. 8 and Fig. 9 show the complete project hardware from multi viewpoints. Meanwhile, the Fig. 10 shows the combination of the project box with the safety helmet to become a complete system that can detect collision.

(a) (b)

Fig. 8 *Project box (a) 3D view of the project; (b) Top view of the project*



(a) (b)

Fig. 9 *Project hardware (a) Side view of the project; (b) Clip attachment for the project box with helmet*

(a) (b)

Fig. 10 *Helmet (a) Side view of the project box with helmet; (b) Front view of the project box with helmet*

3.4 Discussion

The system has been programmed to trigger specific actions, which is sending the SMS location data to registered number as sending emergency alerts when significant changes in the condition that has been setup in MPU6050 data are detected. Results of this study affirm the Safety Helmet with Collision Detection System as an effective tool for collision detection system. The synchronized operation of GSM and GPS module to continuously ready to give the real time location when the triggered was on. The system was not fully automatic, given the user a choice to cancel the automation of SMS transmission by pressing the override button which in case of a false positive or an emergency not covered by the system's predefined algorithms, the override button allows the rider to take immediate control and intervene. The findings also open avenues for future research, focusing on optimizing machine learning to analyze and study the pattern of collision detection data. Moreover, this project can be potential to add any exploring parameters for refining the system for more effectiveness of the whole system such as pre-vehicle collision warning, which integrate buzzer functionality, added with bunch of IR sensor, camera module to warn the user if the possibility of motorcycle and other vehicle and refining the integration of real-time data into meteorological models.

4. Conclusion

The development of an advanced helmet system aimed at enhancing motorcyclist safety and riding experience reveals a multifaceted process. The complexity arises from the intricacies of SMS communication, particularly in synchronizing location inputs from the GPS module for transmission to a registered number. Challenges such as satellite signal reception, weather conditions, and antenna transmission quality can impact the system's functionality. With meticulous adjustment and coding enhancements, the system can achieve the desired output. The GPS module's role extends to a collision detection system, engaging only when the motorcycle reaches a predefined speed. This ensures that the collision detection system responds appropriately, sending SMS alerts based on the gyroscope's Z-axis value. In summary, this innovative helmet system significantly reduces motorcycle accidents in Malaysia through its pivotal collision detection and emergency response systems [7]. While achieving current objectives, ongoing improvements and optimizations promise enhanced performance. Dedication to continuous research and development in motorcycle safety technology is crucial for advancing rider safety and mitigating accidents. This commitment emphasizes the importance of evolving technologies and methodologies to create safer riding environments. As advancements unfold, collaborative efforts will shape the future landscape of motorcycle safety.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design****: M.H.Z;* ***data collection****: M.L.M.E;* ***analysis and interpretation of results****: M.L.M.E, N.M.A.A;* ***draft manuscript preparation****: M.H.Z, M.L.M.E, N.M.A.A. All authors reviewed the results and approved the final version of the manuscript.*

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