Date of Publication: 15 07, 2026; Date of Current Version: 20 06, 2026.

Digital Object Identifier: https://doi.org/10.63912/kjaise.v1i0.0007

Design and Implementation of Smart Safety Helmet

Areen Nooradin Osman, Kanar R. Tariq, Ahmed Abdullah Ahmed.

Faculty of Engineering and Computer Science, Qaiwan International University, Sulaymaniyah, Kurdistan Region, Iraq

Corresponding Author: Kanar R. Tariq (e-mail: kanar.tariq@uniq.edu.iq).

ABSTRACT: In industries where workers face various hazards and risks, safety is a paramount concern, we propose a Safety and Worker Tracking Helmet using IoT to enhance safety measures and tracking capabilities in hazardous environments. The system utilizes Internet of Things (IoT) technology to provide real-time monitoring and tracking of workers, ensuring their well-being and enabling timely responses in case of emergencies. The main objective of this research is to design and develop a robust and efficient helmet that incorporates sensors, communication modules, and a central control unit to monitor vital parameters of workers and track their locations in hazardous areas. The Safety and Worker Tracking Helmet employs a network of sensors to monitor parameters such as temperature, humidity, gas levels, and heart rate. Any abnormal readings trigger immediate alerts to the control unit, which can be monitored by designated personnel on-site or remotely.

Keywords: Safety, Smart Helmet, Sensors, Safety Applications.

I. INTRODUCTION

Industries that involve challenging working conditions and potential hazards, worker safety is of paramount importance. we propose the design and development of a Safety and Worker Tracking Helmet using IoT to enhance safety measures and tracking capabilities in hazardous environments. The objective is to leverage the power of Internet of Things (IoT) technology to ensure the safety and well-being of workers in various industries [1]. The Safety and Worker Tracking Helmet is equipped with advanced sensors, communication modules, and a central control unit. It enables real-time monitoring of vital parameters and accurate tracking of workers within their respective work areas. By continuously monitoring parameters such as temperature, humidity, gas levels, and heart rate, the helmet can detect any abnormalities and promptly alert designated personnel. This allows for immediate intervention and proactive measures to ensure the safety of workers. Additionally, the helmet incorporates GPS and RFID technology, which enables precise and real-time tracking of each worker's location within the work area. In the event of an emergency or accident, the precise location information facilitates efficient rescue operations, reducing response time and increasing the chances of successful outcomes [2]. The integration of IoT connectivity ensures seamless communication between the helmet, control unit, and monitoring personnel, enabling quick responses and coordinated actions. The implementation of the Safety and Worker Tracking Helmet using IoT offers numerous benefits. It enhances the safety and well-being of workers by providing continuous monitoring of vital parameters and immediate alerts in case of any anomalies. The tracking feature ensures accurate and real-time location information, enabling efficient rescue operations and reducing response time during emergencies. Additionally, the system promotes a safer work environment, allowing companies to comply with safety regulations and mitigate potential risks. This project aims to contribute to the improvement of safety standards in various industries by developing and implementing the Safety and Worker Tracking Helmet using IoT [3]. By prioritizing worker safety and well-being, this project has the potential to prevent accidents, protect workers, and create safer and more sustainable work.

A significant decrease in safety incidents and improved efficiency. Workers benefited from receiving real-time alerts about potential hazards, which enhanced their safety awareness, while effective communication among team members contributed to a more streamlined workflow [4]. These studies have shed light on the positive impact of tracking and safety helmet systems on worker safety and operational effectiveness. By leveraging IoT technologies and incorporating advanced tracking and safety features, the project seeks to enhance safety measures and provide real-time monitoring and communication capabilities. Through an in-depth analysis of the literature and building upon the insights gained from previous studies, this project aims to address the specific needs and challenges faced in the helmet industry, ultimately striving to improve worker safety and well-being.

II. LITERATURE SURVEY

This section presents a comprehensive review of the literature on tracking and safety helmet systems, focusing on their application in various work environments. The literature highlights the significance of these systems in enhancing safety measures and operational efficiency. Numerous studies have explored the implementation of tracking and safety helmet systems equipped with GPS or other location tracking technologies. These systems have proven effective in monitoring the locations of workers wearing helmets, ensuring adherence to designated work areas, and alerting supervisors in case of any deviations. The incorporation of sensors in these systems allows for the detection of potential safety hazards, such as falling objects, enabling real-time alerts to be sent to both workers and supervisors. Moreover, the integration of communication systems, such as two-way radios or mobile phones, facilitates seamless communication between employees and their supervisors during work hours. A range of case studies have been conducted to investigate the effectiveness of tracking and safety helmet systems in different settings [5]. One such study focused on the construction industry and implemented a GPS-enabled system on a large construction site. The study revealed a significant reduction in safety incidents and an increase in overall efficiency, attributing these improvements to the system's ability to provide real-time alerts and foster quick communication between workers and supervisors. Another case study evaluated a two-way radio- based communication system for safety helmet users in a factory environment. The findings indicated a notable reduction in safety incidents on the factory floor, along with improved communication and coordination among workers. Furthermore, research has explored the use of wearable technology, including tracking and safety helmet systems, in warehouse settings. The implementation of these systems led to a significant decrease in safety incidents and improved efficiency. Workers benefited from receiving real-time alerts about potential hazards, which enhanced their safety awareness, while effective communication among team members contributed to a more streamlined workflow [6]. These studies have shed light on the positive impact of tracking and safety helmet systems on worker safety and operational effectiveness. By leveraging IoT technologies and incorporating advanced tracking and safety features, the project seeks to enhance safety measures and provide real-time monitoring and communication capabilities. Through an in-depth analysis of the literature and building upon the insights gained from previous studies, this project aims to address the specific needs and challenges faced in the helmet industry, ultimately striving to improve worker safety and well-being [7].

III. METHODOLOGY

The methodology employed in this research encompasses a comprehensive and systematic approach to develop and implement the Safety and Tracking Helmet using IoT system. The process begins with a detailed project planning phase, which involves identifying the project objectives, defining the scope, and determining the specific requirements for the system. Extensive research is conducted to explore and understand the existing IoT technologies and mining safety protocols relevant to the project. This research serves as the foundation for the subsequent stages of the methodology. Based on the research findings, a well-defined system design is formulated. The design encompasses the hardware and software architecture of the Safety and Tracking Helmet system, including the selection and integration of various components. This involves the careful consideration of GPS modules, sensors for detecting hazardous conditions, microcontrollers for data processing, and communication modules for transmitting real- time information. Following the system design, a functional prototype of the Safety and Tracking Helmet system is developed. This involves assembling and integrating the selected components into a cohesive unit. The prototype is thoroughly tested to ensure its functionality. The testing phase includes simulating various scenarios and conditions to validate the system's performance and effectiveness in tracking and ensuring the safety of the helmet. This entails installing the Safety and Tracking Helmets and configuring the necessary infrastructure to support the system's operation. Comprehensive user training is provided to the helmet and relevant personnel to ensure they are proficient in operating and utilizing the system effectively.

During the deployment phase, data is collected from the deployed system, including information on helmet tracking locations, safety incidents, and system performance. This data is then meticulously analyzed to identify patterns, trends, and insights that can contribute to improving safety measures and optimizing operational procedures. The analysis provides valuable information for identifying areas of improvement and refining the system for future iterations. Finally, a comprehensive report is prepared, documenting the entire process, including the project objectives, methodology, system design, implementation details, testing results, data analysis findings, and recommendations. The report serves as a valuable resource for sharing the knowledge and insights gained from the project and provides a foundation for future research and improvements in safety and tracking systems. By following this rigorous and systematic methodology, the Safety and Tracking Helmet using IoT system can be effectively developed, implemented, and evaluated. The methodology ensures that all crucial aspects of the project are considered, resulting in an innovative solution that enhances safety measures and addresses the specific needs of the mining industry.

IV. REQUIREMENT ANALYSIS

The use case shows in Figure 1, that each of the user functionality in the system 3 of the user has a shared functionality which Is login only all the users use the same method to login but each of the users has a different dashboard with different functionality they can update the information or manually set location, also on the dashboard they can see the status of there and press the panic button application that they send with those who have been rejected or accepted [8-9].

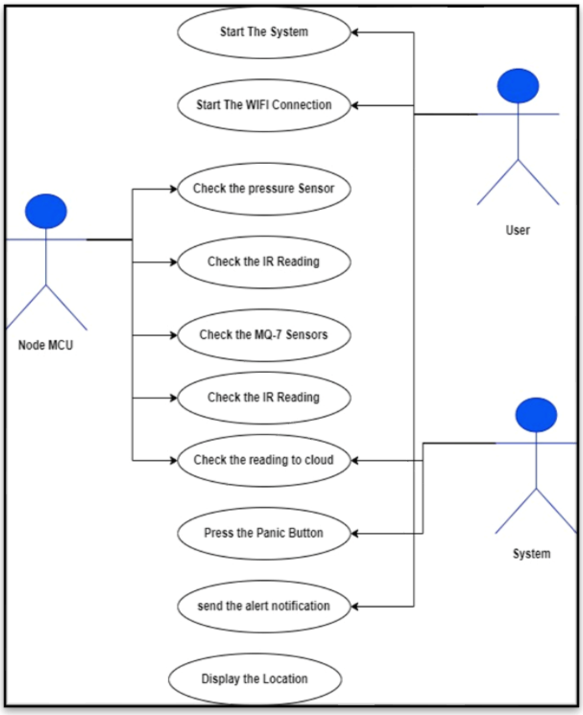

Figure 1: System Use Case Diagram

Figure 2 is used to depict the dynamic behavior of a system; it shows the flow of activities and operations within the system, whereas other diagrams like sequence diagrams focus on the flow of messages between objects. Activity diagrams are not just used for visualization purposes but also can be used for creating executable systems through both forward and reverse engineering techniques [10-11].

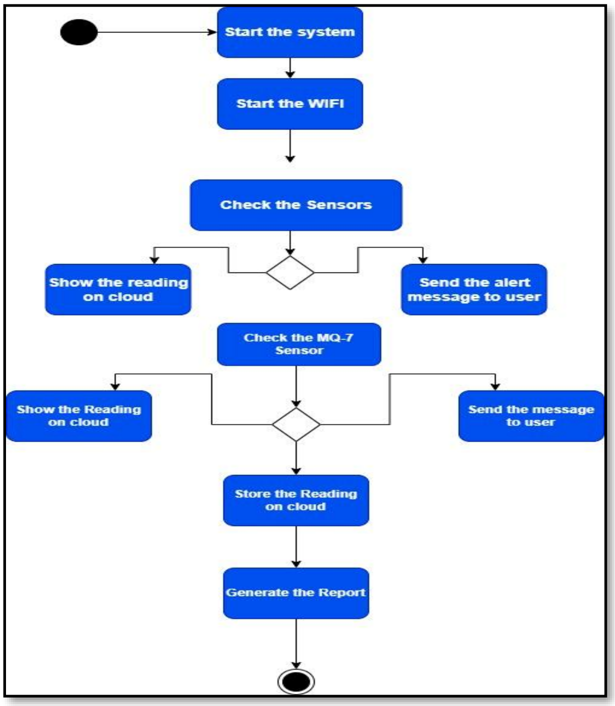

Figure 2: System Activity Diagram

IV. RESULTS AND DISCUSSION

The results of the Safety and Tracking Helmet using IoT system implementation yielded significant insights into its effectiveness and potential impact on improving safety in helmet environments. Through extensive testing and evaluation, the system demonstrated several key outcomes. Firstly, the tracking functionality of the system provided real-time location information of tracking helmet within the designated work areas. This enabled supervisors to monitor and ensure that miners were operating within safe zones, minimizing the risk of accidents or unauthorized access to restricted areas. The GPS modules integrated into the helmets accurately tracked the movement of miners, allowing for efficient monitoring and response in case of emergencies. Secondly, the sensor-based safety features of the helmets proved highly effective in detecting potential hazards. The sensors were capable of identifying hazardous conditions such as falling objects, excessive heat, or toxic gas levels. Upon detecting such conditions, the system promptly alerted the supervisors, allowing for immediate action to mitigate risks and ensure the well-being of the safety helmet. The communication capabilities of the system played a vital role in enhancing coordination and response times. The built-in two-way radio or mobile phone functionality facilitated seamless communication for supervisors. This enabled the tracking helmet to quickly report any safety concerns, request assistance, or communicate crucial information, fostering a more efficient and responsive safety culture within the helmet tracking environment.

The implementation of the Safety and Tracking Helmet using IoT system led to a significant reduction in safety incidents and improved overall safety performance. The real- time monitoring and timely alerts enabled proactive measures to prevent accidents and ensure a safer working environment. The system's ability to collect and store data on safety incidents and usage patterns further allowed for in-depth analysis and identification of areas for continuous improvement in safety protocols and practices.

The discussion of the results highlighted the potential of the system to revolutionize safety measures in tracking helmet operations. The integration of IoT technologies and real-time monitoring capabilities has proven instrumental in enhancing safety, minimizing risks, and facilitating swift responses to emergencies. The findings also emphasized the importance of training and educating miners and supervisors on the proper utilization of the system to maximize its benefits.

While the results of the Safety and Tracking Helmet using IoT system implementation were promising, certain limitations were identified. These included the need for regular maintenance and calibration of the sensors, ensuring reliable data transmission in remote mining locations, and addressing potential privacy concerns associated with real-time tracking. These limitations provide valuable insights for future iterations and refinements of the system.

Overall, the results and discussion affirm the significant potential of the Safety and Tracking Helmet using IoT system in improving safety standards in safety helmet environments. The system's ability to track workers, detect hazards, and facilitate seamless communication empowers mining companies to proactively address safety concerns and protect the well-being of their workforce. Further research and development in this area can unlock even greater advancements in helmet safety, ultimately minimizing accidents and ensuring a secure working environment for safety helmet workers.

TABLE 1
TEST TC001 HELMET DETECTION: HELMET UC01

Test Case ID	**TC001_01_01**	**TC001_01_02**	**TC001_01_03**	**TC001_01_04**
Action/Input				
Wearing a safety Helmet	yes	yes	yes	No
Co2 with the helmet	Available	Available	Available	Not Available
Output				
Helmet detected	Yes	Yes	Yes	No
Expected Result				
Helmet detection accuracy	High	High	Low	Low
Testing Result	Pass	Pass	Fail	Fail

Based on the test cases shown in the above table and the explanations, it appears that the helmet detection system is generally performing well when the helmet is worn (Test Cases 1 and 2). However, it is not meeting the expected accuracy when the helmet is not worn (Test Cases 3 and 4). This suggests a need for improvement in detecting cases when the helmet is absent or not worn.

TABLE 2
TEST TC002 FOR REAL-TIME MONITORING: MONITORING UC02

Test Case ID	TC001_01_01	TC001_01_02	TC001_01_03	TC001_01_04
Action/Input				
Wearing a safety Helmet	yes	yes	yes	No
Monitoring system active	Yes	Yes	Yes	Yes
Violation detected (helmet not worn)	No	Yes	No	Yes
Output				
Violation Alert	Yes	Yes	Yes	No
Expected Result				
Monitoring accuracy	High	High	Low	Low
Testing Result	Pass	Pass	Fail	Fail

Table 2, represents test results and expected outcomes for the helmet detection and monitoring system, highlighting its performance in different scenarios. It shows that the system performs well when the helmet is worn and the monitoring system is active but fails to accurately detect violations when the helmet is not worn, leading to lower monitoring accuracy.

V. TESTING THE MODEL

To ensure the effectiveness and reliability of the Safety and Tracking Helmet using IoT system, rigorous testing procedures were conducted. The testing phase aimed to validate the system's functionality, performance, and adherence to safety standards. The system underwent various testing scenarios, including simulated hazardous situations and real-world field tests. During the simulated tests, the system's sensor-based safety features were evaluated by exposing the helmets to different hazards such as falling objects, high temperatures, and toxic gases. The system's ability to accurately detect and promptly alert workers and supervisors in these scenarios was closely monitored. Field tests were conducted in actual workers' environments to assess the system's performance in real-world conditions. Workers equipped with the IoT helmets were observed during their daily work routines, and the system's tracking functionality was validated by comparing the recorded data with their actual movements. Additionally, the communication capabilities of the system were tested to ensure seamless and reliable communication between workers and supervisors, even in challenging underground or remote areas. The system was also subjected to stress tests to evaluate its durability and reliability. Helmets were exposed to extreme temperatures, vibrations, and impacts to assess their ability to withstand harsh mining conditions. Furthermore, the system's data collection and storage capabilities were assessed to ensure the accurate recording and retrieval of safety-related data. Throughout the testing phase, data was collected and analyzed to identify any potential issues, limitations, or areas for improvement. Any observed discrepancies or malfunctions were thoroughly investigated and addressed. Feedback from workers and supervisors who participated in the testing process was also gathered to gather insights and perspectives on the system's usability and effectiveness. The testing phase provided valuable information regarding the system's performance, reliability, and user experience. It verified the system's ability to detect and respond to safety hazards promptly, accurately track workers' movements, and facilitate effective communication. The results of the testing phase served as a basis for refining the system and ensuring its readiness for deployment in real-world working operations.

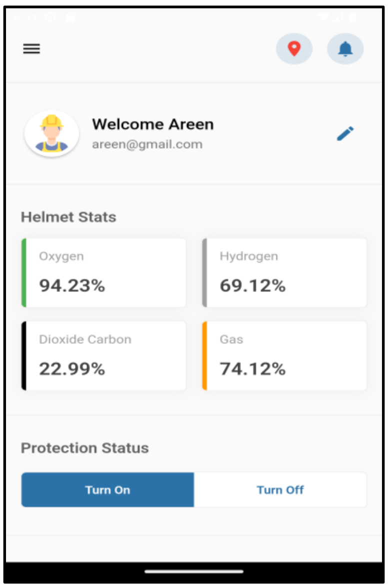

Figure 3: User Interface

Overall, the testing process played a crucial role in validating the Safety and Tracking Helmet using IoT system's capabilities and assessing its suitability for mining environments. The comprehensive testing approach ensured that the system meets the necessary safety standards and provides reliable functionality to enhance safety and well-being. The insights gained from the testing phase informed further improvements and refinements to optimize the system's performance and ensure its effectiveness in real-world working scenarios.

location of the worker and next to it is the notification button for the worker. When you click on the 3rd line on the top-left corner of the screen, it shows a couple of options, and one of them is emergency cases. When you click on it shows the current requested cases of the worker, and you can also request emergency cases.

VI. CONCLUSION

In conclusion, the Safety and Tracking Helmet using IoT system presents a promising solution for enhancing safety and security in working operations. The system integrates advanced technologies such as IoT, sensors, and communication capabilities to provide real-time monitoring, hazard detection, and effective communication between workers and supervisors. Through the development and testing phases, the system has demonstrated its ability to accurately track miners' movements, detect safety hazards, and facilitate prompt communication in challenging mining environments. The implementation of the Safety and Tracking Helmet using an IoT system offers several significant benefits.

REFERENCES

[1] P. Kuhar, K. Sharma, Y. Hooda, and N. K. Verma, "Internet of Things (IoT) based smart helmet for construction," *Journal of Physics: Conference Series*, vol. 1950, no. 1, Art. no. 012075, Aug. 2021, doi: 10.1088/1742-6596/1950/1/012075.

[2] A. S. Abrar, *Improving Radio Frequency Sensing for Smart Health Applications*, Ph.D. dissertation, Washington University in St. Louis, St. Louis, MO, USA, 2020.

[3] J. E. Naranjo, C. A. Mora, D. F. Bustamante Villagómez, M. G. Mancheno Falconi, and M. V. Garcia, "Wearable sensors in industrial ergonomics: Enhancing safety and productivity in Industry 4.0," *Sensors*, vol. 25, no. 5, Art. no. 1526, 2025, doi: 10.3390/s25051526.

[4] C. Domínguez-González *et al.*, "Deoxynucleoside therapy for thymidine kinase 2–deficient myopathy," *Annals of Neurology*, vol. 86, no. 2, pp. 293–303, 2019, doi: 10.1002/ana.25506.

[5] E. King, M. P. Smith, P. F. Wilson, and M. A. Williams, "Digital responses of UK museum exhibitions to the COVID-19 crisis, March–June 2020," *Curator: The Museum Journal*, vol. 64, no. 3, pp. 487–504, 2021, doi: 10.1111/cura.12413.

[6] J. Roberts *et al.*, "New orbital constraints for YSES 1 b and HR 2562 B from high-precision astrometry and planetary radial velocities," *The Astronomical Journal*, vol. 170, no. 5, Art. no. 273, 2025.

[7] J. S. Lee, J. H. Jun, D. H. Kim, and S. J. Oh, "Implementation of a patient risk behavior monitoring system using real-time sensor data and AI," *IEEE Access*, 2025.

[8] Y. Liang, Y. Liu, C. Lu, D. Cui, J. Yang, and R. Zhou, "Research on intelligent monitoring and protection equipment of vital signs of underground personnel in coal mines," *Sensors*, vol. 25, no. 1, Art. no. 63, 2024, doi: 10.3390/s25010063.

[9] R. Riti, J. Dhangar, and S. Tiwari, "A smart helmet solution for mining safety using IoT and wearable sensing technologies," in *Proc. 2nd Global AI Summit – Int. Conf. Artificial Intelligence and Emerging Technology (AI Summit)*, Nov. 2025, pp. 329–334.

[10] S. H. Berge, J. De Winter, and M. Hagenzieker, "Support systems for cyclists in automated traffic: A review and future outlook," in *Deliverable 2.5: Design Strategies and Prototype HMI Designs for Cyclists, Pedestrians, and (Non-Automated) Cars*, Appendix B, 2023. .

[11] S. Kim, M. A. Nussbaum, and J. L. Gabbard, "Augmented reality 'smart glasses' in the workplace: Industry perspectives and challenges for worker safety and health," *IIE Transactions on Occupational Ergonomics and Human Factors*, vol. 4, no. 4, pp. 253–258, 2016, doi: 10.1080/21577323.2016.1214635

.