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IN COLLABORATION
JABATAN KEJURUTERAAN ELEKTRIK
POLITEKNIK SULTAN MIZAN ZAINAL ABIDIN
(PSMZA)



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It is with great pride and immense pleasure that I commend the Electrical Engineering Innovation Competition and Exhibition 2026 on achieving another historic milestone. This success was made possible through a synergistic collaboration between Politeknik Sultan Mizan Zainal Abidin (PSMZA) and Universiti Teknologi MARA (UiTM). Our partnership exemplifies the spirit of unity and the shared vision required to bring this meaningful publication to fruition.

We stand at a remarkable juncture in human history, where electrical engineering continues to be the beating heart of global progress. From the expansion of smart grids and renewable energy to breakthroughs in artificial intelligence and advanced telecommunications, the work of electrical engineers is actively rewiring our world. The innovative prototypes and systems documented in this compilation serve as a testament to the rich pool of ideas cultivated within our two esteemed institutions.

Bringing an endeavor of this magnitude to life requires extraordinary dedication. I want to extend my deepest gratitude to the joint organizing committee from both UiTM and PSMZA, whose tireless efforts have transformed this shared vision into reality. To all our contributors and partners, thank you for your unwavering support and for investing in the next generation of engineering pioneers.

I wish all the participants the very best of luck in their future endeavors, and I hope everyone who engages with this body of work leaves inspired by the limitless possibilities of electrical engineering.

Thank you.

FOREWORD BY HAJI MOHD DASRI BIN CHE MOK @ ADNAN KJ JKE PSMZA

Assalamualaikum Warahmatullahi Wabarakatuh and Salam Sejahtera.

Alhamdulillah, praise be to Allah SWT for His blessings and guidance that have enabled the successful publication of the Electrical Engineering Innovation Competition & Exhibition 2026 (EEICE 2026) Extended Abstracts. This publication represents another significant milestone in the ongoing academic collaboration between the Department of Electrical Engineering, Politeknik Sultan Mizan Zainal Abidin (PSMZA) and the Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Terengganu.

The rapid advancement of technology and the increasing demand for innovative engineering solutions continue to challenge and inspire future engineers. The collection of extended abstracts presented in this volume showcases the creativity, technical competence and problem-solving capabilities of our students. Through their final year projects (FYP), students have demonstrated their commitment to addressing contemporary issues in areas such as renewable energy, Internet of Things (IoT), automation, smart systems, sustainability and digital transformation.

I would like to express my sincere appreciation and gratitude to the editorial committee, academic staff and all contributors whose hard work and commitment have made this publication possible. My heartfelt congratulations also go to all participating students for their determination, creativity and achievements.

It is my hope that this collection of extended abstracts will serve as a useful reference and source of inspiration for future researchers and students. May the knowledge and innovations presented herein continue to foster a culture of continuous learning, research excellence and technological advancement in the field of Electrical Engineering.

Thank you.

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SMART HELMET FOR RIDER

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Abstract: This project is designed to provide an accident detection system and real-time location of a motorcycle rider by using “Smart Helmet”. It is constructed with ESP32 microcontroller, NEO-6M GPS module and MPU6050 sensor. The HUD provides the rider with a speedometer, and the accident detection system will send an emergency message with the rider's location details to Telegram based on the system's location. Moreover, Thinger.io platform allows users to keep track of the helmet's real-time location and speed. Test results show that the functionality to detect an accident, send alerts and display speeds can be done effectively. To sum up, the Smart Helmet is an excellent safety device given its ability to detect the accident, monitor the situation in real-time, and alert to emergency.

Keywords: Smart Helmet, Motorcycle Safety, Accident Detection, GPS Tracking, ESP32.

INTRODUCTION

Today motorcycle accidents are a significant cause of death and injury. Post-accident, many times the rider may not be able to reach out for assistance immediately, causing a delay in emergency response. This project proposes a Smart Helmet for accident detection, real-time location tracking and integrating a head-up display (HUD) for speed monitoring to enhance the safety of the rider to overcome this challenge.

The Smart Helmet can determine falls or crashes with a gyroscope sensor and send an emergency message with the rider's location. A GPS module will be fitted to allow for real-time monitoring, and an OLED screen will function as a HUD and alert the rider to their speed and increase awareness. The system is managed with ESP32 microcontroller and it is connected to applications like Telegram, Thinger.io for emergency notifications and monitoring.

These technologies are merged in the Smart Helmet, which also provides constant monitoring and rider protection, and aids in minimizing emergency response time. The Internet of Things (IoT) can be utilized to improve road safety, and to make motorcycles more comfortable to ride. This project demonstrates some of the ways of achieving this.

METHODOLOGY

This section explains the operation of the Smart Helmet for Rider System project. The project's block diagram is shown in Figure 1.

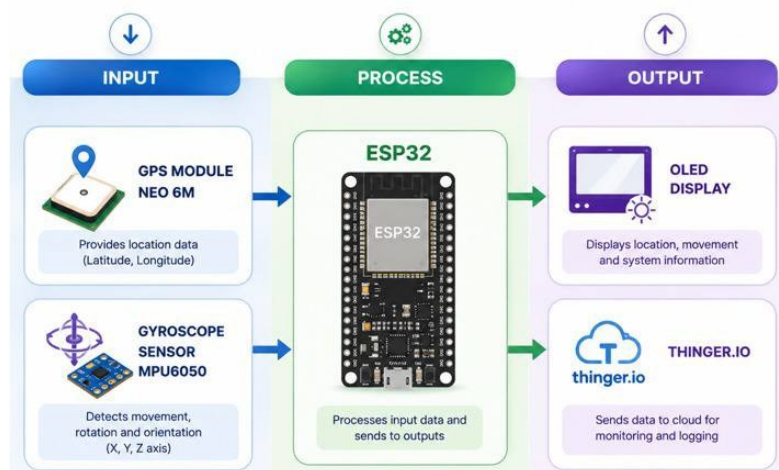


Figure 1. Block diagram of smart helmet for rider

The GPS module Neo-6M and Gyroscope Sensor MPU6050 sensor collect location and movement data. The ESP32 processes the data. The system then displays the rider's speed on the OLED and sends the location to Thinger.io application for real-time tracking. If an accident is detected, an emergency notification is sent through the Telegram app.

RESULT AND DICUSSION

The prototype is tested in various scenarios as shown in the results below:

Table 1. Smart Helmet for Rider Testing Result

Function	Test Scenario	Result
Accident Detection	Helmet Tilted/ fall detected	Successfully triggered by sudden impact (G-force)
GPS Tracking	Rider Location Obtained	Successfully displayed rider location on application
Telegram Notification	Accident Detected	Emergency message with GPS location sent successfully
Thinger.io Application	Motorcycle speed and live location	Rider Location and speed updated with minimal delay

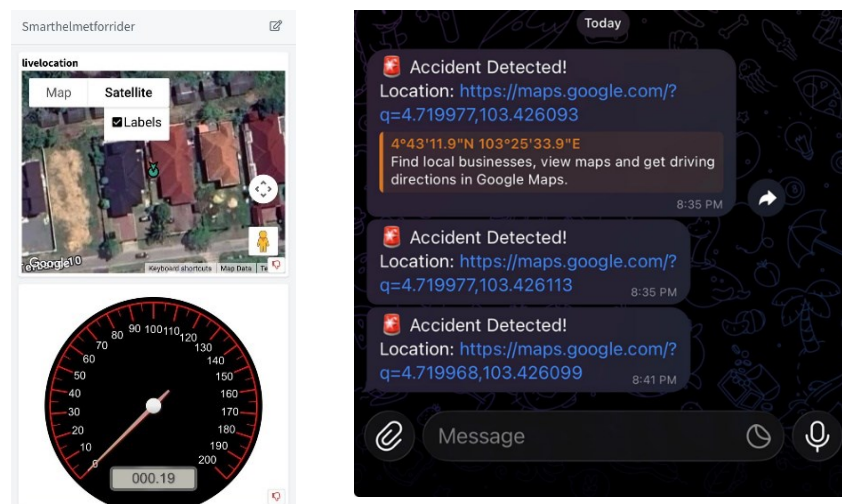


Figure 2. Thinger.io and Telegram Application

The Smart Helmet includes an accident notification system using Telegram. When an accident is detected by the MPU6050 sensor, an alert message with the GPS location is sent to a predefined contact. The Thinger.io platform is used to monitor the helmet's real-time location and speed through an online dashboard. This system helps improve rider safety by providing quick accident alerts and continuous tracking.

CONCLUSIONS

In conclusion, the Smart Helmet project was well advanced and project objectives were achieved in the early days of the project. The system integrates several components: the ESP32 microcontroller, MPU6050 module, NEO-6M GPS module, OLED display, and push button, among others. The system is made up of several components, including the ESP32 microcontroller, MPU6050 module, NEO-6M GPS module, OLED display and push button, among others. In the event of an accident, it will automatically send out an alert with the rider's location to the Telegram service and also request the prompt response from the emergency contact. Testing and verification of hardware and software are tested to ensure proper functioning of the system. To sum up, the Smart Helmet is an intelligent helmet solution that takes advantage from the IoT technology for the safety of the motorcycle rider, with features of accident detection, real-time tracking and emergency notification.

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AI-DRIVEN REAL-TIME FALL DETECTION AND EMERGENCY NOTIFICATION SYSTEM FOR HOSPITAL WARDS

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Abstract: Accidental falls in hospital wards remain a major cause of patient injury, yet traditional monitoring relies on inconsistent manual nursing surveillance. This paper introduces an AI-driven, real-time fall detection and emergency notification system designed for clinical settings. By leveraging computer vision and skeletal pose estimation techniques-utilizing MediaPipe framework alongside OpenCV and TensorFlow, the system extracts skeletal key points and analyzes human posture from live camera feeds. Implemented on a compact Raspberry Pi single-board computer, the AI model achieves 95% detection accuracy across standing, sitting, and falling postures. When a fall occurs, the system immediately triggers a visual alarm light and dispatches mobile alerts to medical personnel within seconds via an Internet of Things (IoT) network. This project offers an efficient, low-cost solution to automate fall detection, drastically reduce emergency response times, and relieve nursing workload burdens..

Keywords: Artificial Intelligence, Fall Detection, MediaPipe, Raspberry Pi, Internet of Things

INTRODUCTION

The World Health Organization defines a fall as inadvertently coming to rest on the ground or a lower surface (WHO, 2007). In clinical settings, accidental falls represent a major threat to patient safety and a leading cause of hospital injuries globally (Yasan et al., 2020). High-risk individuals, including elderly and post-operative patients, require vigilant surveillance to prevent severe outcomes such as fractures, head trauma, extended hospitalizations, and increased healthcare expenditures (Vassallo et al., 2009; Kulurkar et al., 2023).

In-hospital falls stem from intrinsic risk factors (e.g., age, physical/cognitive impairment, psychotropic medications) and extrinsic environmental hazards (e.g., slippery surfaces, inadequate lighting, non-sturdy furniture) (Lee et al., 2022; Takase, 2023). Traditional fall mitigation relies on manual observation by nursing staff; however, staffing shortages and heavy workloads make continuous manual monitoring impractical, especially during night shifts (Heng et al., 2022). While wearable accelerometer devices have been introduced to send emergency SMS alerts (Padme et al., 2023), they frequently fail in real-world scenarios due to patient non-compliance and physical discomfort (Chang et al., 2021).

To overcome these challenges, this study introduces an automated, real-time fall detection and notification system which utilizes AI-driven pose estimation using MediaPipe framework to track human skeletal key points (such as shoulders, hips, and knees) from digital video feeds without requiring

physical contact (Stenum et al., 2021). Upon detecting a fall event, the system instantly triggers a local visual alarm and sends mobile alerts to medical staff, enabling rapid clinical intervention.

METHODOLOGY

The development of this project was structured into two integrated phases: hardware architecture and AI model and software development. For the hardware architecture phase, A Raspberry Pi serves as the core edge processor, receiving live video input from a USB camera. Upon fall detection, it activates a dual-alert system: a local flashing light controlled via a relay module for immediate visual warning, and an automated push notification dispatched to healthcare staff via the Blynk IoT platform over Wi-Fi.

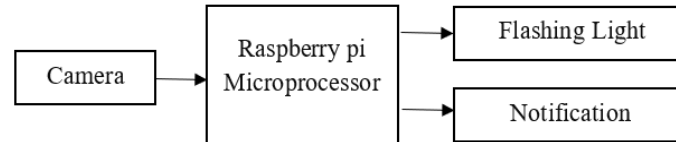


Figure 1. Block diagram of Ai-Driven Real-Time Fall Detection and Emergency Notification System

For the AI model and software development phase, the system was programmed in Python, utilizing AI pose estimation using MediaPipe framework to analyze skeletal key points. A posture classification model was trained across three posture categories (standing, sitting, and falling). A dataset of 300 diverse images (100 per category, varying by gender, height, and environment) was used to achieve high detection accuracy. The trained model was embedded into the main script to process live camera frames and instantly trigger local relay outputs. In addition, a signal is sent to the Blynk server to trigger a notification to the health worker's mobile phone when a fall is detected.



Figure 2. Real-time skeletal key point extraction and posture classification of standing

RESULT AND DISCUSSION

The functional reliability of this project was evaluated through controlled laboratory testing across three distinct human postures: standing, sitting, and falling.

- Standing Posture (Figure 3a): The system correctly extracted anatomical landmarks and identified the "Stand" status. Local alarms and IoT notifications remained inactive.
- Sitting Posture (Figure 3b): The classification system seamlessly transitioned from "Stand" to "Sit" as the subject sat down. No false alerts were triggered, demonstrating spatial classification accuracy between sitting and falling states.

- Falling Posture (Figure 3c): Upon detecting a sudden downward transition and prone posture, this project instantly updated the status to "Fall," automatically activating the relay-driven visual beacon light and transmitting an emergency cloud alert.

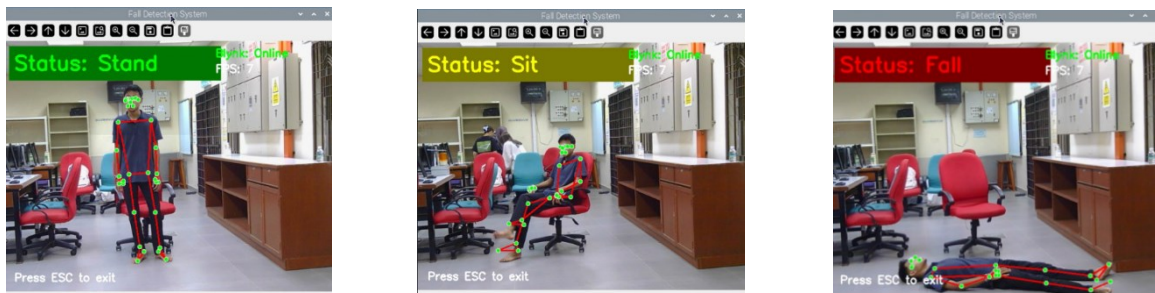


Figure 3. a) Standing Detection b) Sitting Detection c) Fall Detection

The system dispatched a real-time push notification via the Blynk IoT platform (Figure 4) reading "FALL DETECTED! Please check immediately". The message arrived at the mobile receiver within seconds, complete with auditory alerts and vibration feedback, confirming the system's operational capability for rapid clinical intervention.

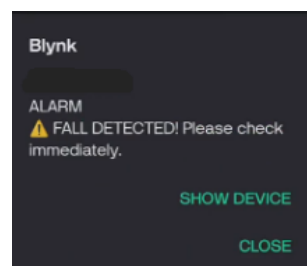


Figure 4. Notification in Blynk application

CONCLUSIONS

The Ai-Driven Real-Time Fall Detection and Emergency Notification System for Hospital Wards successfully fulfills its objective of delivering automated, real-time fall detection and instant alerting in hospital ward environments. Combining computer vision pose estimation with an IoT framework enables a dual-response mechanism—a local visual beacon and a mobile push notification—without requiring patient contact or manual nurse oversight. Implemented on a low-cost Raspberry Pi, this project offers an accessible solution to reduce response times, prevent severe fall complications, and optimize healthcare resource allocation. The framework directly supports UN Sustainable Development Goals 9, 10, and 11. Subsequent enhancements will integrate night-vision imaging for dark ward environments and transition to higher-performance edge processors (e.g., NVIDIA Jetson Nano) to increase inference speed and multi-patient tracking capacity.

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E-PASS: STUDENT OUTING AUTHORIZATION SYSTEM

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Abstract: Student entry and exit management in campus residential areas (kamsis) can be inefficient due to manual approval, system interruptions, and logbook recording. This study presents E-PASS: Student Outing Authorization System, an IoT-based solution designed to automate and improve student outing management using QR-code technology. The system integrates ESP32-CAM, Arduino Uno, LCD, push buttons, LEDs, buzzer, Python, and Google Sheets. Students scan their identification QR code for verification before selecting the appropriate outing status. Verified student information, status, date, and time are automatically recorded in Google Sheets for real-time monitoring. Prototype testing successfully demonstrated QR-code recognition, student verification, status selection, real-time feedback, and automatic data logging. Despite limitations related to lighting conditions and serial communication, E-PASS provides a practical, efficient, and reliable solution that reduces manual data-entry errors and supports digital transformation in campus residential management.

Keywords: E-PASS, QR Code, ESP32-CAM, Arduino Uno, IoT, Student Outing, Google Sheets

INTRODUCTION

Student movement in and out of campus residential areas requires effective monitoring to maintain accurate records and support residential management. In the existing process, students may be required to enter their student identification or identification card number through the SPMP system at the guard house. For activities such as returning to their hometown, staying overnight outside the residential area, or returning late, students may need to apply through SPMP I-Kamsis several days earlier and wait for approval from the residential fellow. This process may become inefficient when approval is delayed, the system is slow or unavailable, or manual logbook recording is required.

Digital technologies such as QR codes, web-based applications, RFID, and Internet of Things (IoT) platforms have increasingly been applied to attendance and student movement monitoring. Previous systems have demonstrated that QR codes can facilitate student identification and attendance recording [1], while digital outing systems can reduce dependence on manual approval and paper-based processes [2]. Web-based electronic outing systems have also been proposed to improve accessibility and management of student outing records [3]. Other approaches integrate Arduino, online databases, RFID, and notification mechanisms to improve monitoring and communication [4].

Based on these developments, the E-PASS: Student Outing Authorization System was developed to provide a simpler and more systematic method of managing student entry and exit from campus residential areas. The system uses QR code scanning based on student identification to record student movements digitally. Students can select relevant outing categories, including daily outings, returning to their hometown, late return, and overnight stay outside the residential area [5].

The main objectives of E-PASS are to develop a system capable of updating student entry and exit records, simplifying the existing outing process, transmitting student information for residential management records, and displaying the selected outing status and relevant student information. The

system is intended to reduce processing time and fellows' workload while improving the accuracy, accessibility, and efficiency of student movement records.

METHODOLOGY

The development of E-PASS followed a systematic process consisting of problem identification, information gathering, planning and component selection, hardware setup, programming, Google Sheets integration, testing and troubleshooting, and final implementation.

The system combines hardware and software components. The primary hardware includes an ESP32-CAM, Arduino Uno, LCD display, four push buttons, LEDs, buzzer, resistors, prototype board, and ESP32-CAM expansion board. The ESP32-CAM functions as the QR code scanning device, while the Arduino Uno controls the input and output components. The LCD provides instructions and system feedback, the push buttons enable students to select their outing status, and the LEDs and buzzer provide visual and audio indications.

The operational process begins when the ESP32-CAM is activated and the LCD prompts the student to scan a QR code. The ESP32-CAM detects the QR code and transfers the captured information to a Python program for verification. Python communicates with the Arduino to determine whether the scanned information corresponds to registered student data.

When verification is successful, the green LED and buzzer are activated and the LCD displays the relevant information. The student then selects the appropriate outing status using the push buttons. The Arduino sends the selected information to Python, which subsequently uploads the student's information, outing status, date, and time to Google Sheets. Google Sheets therefore functions as an online database that allows the residential management to access and monitor student movement records. If verification is unsuccessful, the system rejects the QR code and no student outing data are recorded.

Software development involved programming and integration between the ESP32-CAM, Arduino Uno, Python, and Google Sheets. The programs were tested repeatedly during development to identify communication and operational problems. Hardware and software integration was subsequently tested to ensure that QR detection, verification, user input, display output, and data recording operated according to the intended workflow. The project's block diagram is shown in Figure 1.

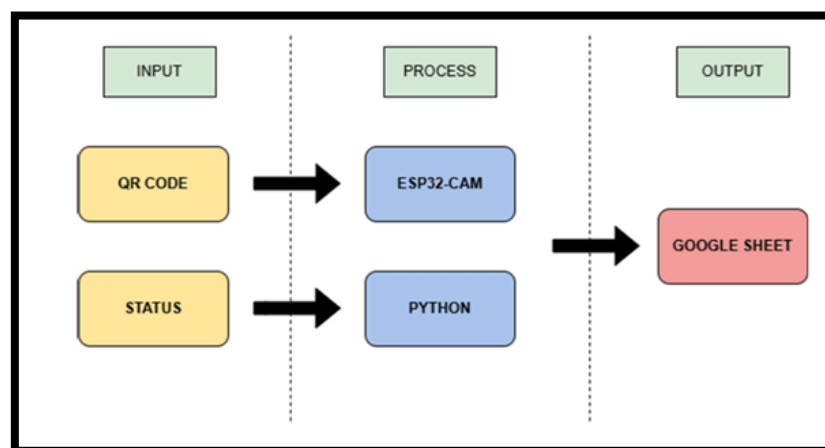


Figure 1. Block diagram of E-PASS

The proposed system operates by combining ambient light detection, motion sensing, and time-based control to manage dormitory lighting automatically. The LDR circuit activates the lighting system during nighttime, while the PIR sensor detects human movement and switches on the toilet light when occupancy is detected. Additionally, time-based control and PWM dimming are implemented to adjust light brightness during late-night hours, reducing electricity consumption while maintaining adequate illumination.

RESULT AND DISCUSSION

The completed E-PASS prototype successfully demonstrated the integration of the ESP32-CAM, Arduino Uno, Python application, LCD, input/output components, and Google Sheets. The ESP32-CAM functioned as the image-capturing and QR-code detection unit, extracting student information for verification and processing. The Arduino Uno managed the user-interface components, including the LCD, push buttons, buzzer, and LEDs. The LCD displayed real-time information and instructions, while visual and audio indicators provided feedback on QR-code verification. Students could also select the appropriate outing category using push buttons before recording.

The integration of Python and Google Sheets enabled student ID, outing status, date, and time to be recorded automatically. This automated process reduced dependence on handwritten logbooks and manual data entries while enabling residential fellows to monitor student movements digitally. Functional testing showed effective communication between hardware and software components, with fast response and reliable data transmission. Cloud-based recording also improved record-management efficiency and reduced potential human errors.

The findings indicate that E-PASS achieved its main objectives, including QR-code verification, outing status selection, real-time feedback, and automated data recording. The prototype demonstrates the potential of low-cost microcontroller and IoT technologies to address administrative challenges in educational institutions. The developed prototype is shown in Figure 2.

However, QR-code recognition may be affected by poor lighting conditions, while dependence on serial communication may limit future scalability. Improvements could include direct Wi-Fi communication, enhanced QR-code processing, stronger security mechanisms, and mobile or web-based monitoring. Cloud databases such as Firebase or MySQL Cloud, together with RFID or facial recognition, could further enhance system security and scalability. Overall, E-PASS provides a practical foundation for developing a more efficient, reliable, and comprehensive smart residential management system for future institutional applications.

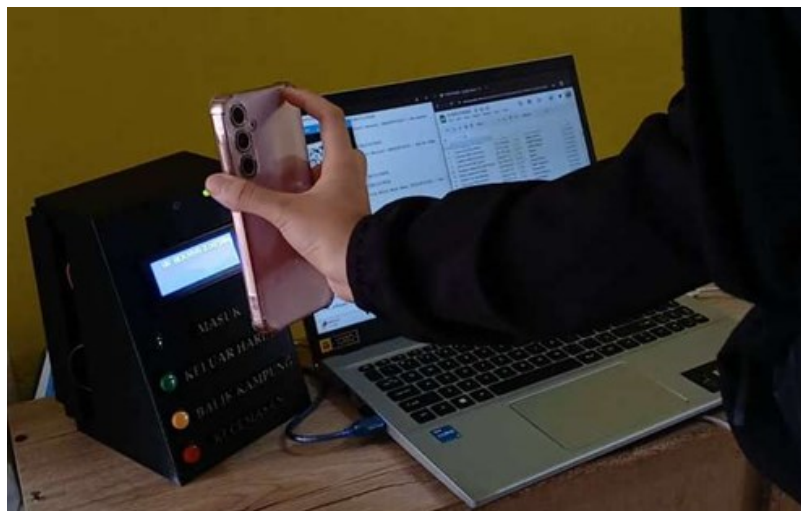


Figure 2. Prototype of E-PASS

CONCLUSIONS

The E-PASS: Student Outing Authorization System was successfully developed as a QR-code-based solution for improving the management of student entry and exit from campus residential areas. The system integrates an ESP32-CAM, Arduino Uno, Python, LCD, input/output components, and Google

Sheets to automate student identification, outing status selection, and movement data recording. The developed prototype successfully performed its main functions, including scanning student QR codes, verifying information, displaying system feedback, receiving outing status selections, and automatically recording student information with date and time. The integration of hardware and software contributes to improved data accuracy, reduced manual recording, and more efficient monitoring of student movements. Future improvements should focus on wireless communication, enhanced QR-code recognition, stronger authentication and data security, cloud database implementation, and mobile or web-based monitoring. With these improvements, E-PASS has the potential to be implemented not only in polytechnics but also in other educational institutions requiring systematic and real-time monitoring of student movements.

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WATER LEVEL MONITORING SYSTEM

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Abstract: This study presents the development of a Water Level Monitoring System, a real-time water level monitoring system developed to help reduce the risk of water overflow in domestic water tanks and small-scale industrial applications. The system integrates an ESP32 microcontroller with an HC-SR04 ultrasonic sensor to measure water levels and wirelessly transmit data via Wi-Fi to the Internet of Things (IoT) Blynk platform. LED indicators are used to display the water level status locally, while warning notifications are sent to users when the water level reaches a predetermined critical threshold. System testing was conducted by simulating various water levels to evaluate measurement accuracy and the response time of notification delivery. The test results showed that the system could detect water levels ranging from 2 cm to 400 cm with an error of less than 5%. In addition, the Blynk dashboard received data updates at 2-second intervals, while warning notifications were delivered within 3 seconds after the water level reached the specified high threshold. These findings indicate that the developed system has the potential to serve as a cost-effective IoT-based solution for real-time water level monitoring while providing an early warning mechanism to reduce reliance on manual monitoring..

Keywords: Internet of Things (IoT), ESP32, Water Level Monitoring System, ultrasonic sensor, Blynk.

INTRODUCTION

Water resource management is an important aspect of daily life, particularly for domestic use and small-scale industrial applications. Effective water level monitoring is necessary to ensure proper water supply management and to reduce the risk of water overflow, which may result in resource wastage and property damage. However, conventional monitoring methods still largely rely on manual inspection. This approach requires users to be physically present at the tank location and may be impractical, particularly when the tank is located in a difficult-to-access area.

The development of Internet of Things (IoT) technology has created opportunities for monitoring systems that enable data to be collected and monitored remotely in real time [1]. IoT-based water level monitoring systems can help users obtain information about water levels without the need for physical inspection. Although various IoT-based water level monitoring systems have been developed, there remains a need to integrate water level detection, status indication, and warning notification functions into a single system that is simple and cost-effective. In addition, measurement accuracy and information transmission response time need to be evaluated to ensure that the system provides reliable information to users.

Therefore, this study develops a Water Level Monitoring System based on an ESP32 microcontroller, HC-SR04 ultrasonic sensor, and Blynk IoT platform [2][3]. The proposed system enables water levels to be detected in real time, displayed through LED indicators, and monitored remotely using the Blynk application. Warning notifications are also provided when the water level reaches a predetermined critical threshold. This study focuses on evaluating the accuracy of water level detection and the efficiency of information and notification delivery to users.

METHODOLOGY

The methodology of this study consists of four main phases: concept development, system design, prototype development, and system testing. Each phase was carried out to ensure that the water level monitoring system functioned as intended and fulfilled the objectives of the study.

4.1 System Design

The developed system uses an ESP32 microcontroller as the main processing unit and an HC-SR04 ultrasonic sensor as the water level detection device [4]. The ultrasonic sensor measures the distance between the sensor and the water surface based on the reflection of ultrasonic waves. The measurement data are then processed by the ESP32 to determine the water level status [5].

4.2 Internet of Things Integration

To enable remote monitoring, the ESP32 is connected to a Wi-Fi network and integrated with the Blynk IoT platform [2]. The Blynk library serves as an interface between the hardware system and the Blynk application. The processed water level data are transmitted to the Blynk dashboard, allowing users to monitor the water level status in real time.

4.3 Indicator and Warning Mechanism

The system is also equipped with LED indicators to display the water level status locally. When the water level reaches the predetermined high threshold, the system triggers a warning notification through the Blynk platform. This mechanism enables users to receive information about the water level condition without being physically present at the tank location.

4.4 System Testing

System testing was conducted by simulating various water levels to evaluate the ability of the HC-SR04 sensor to detect changes in water level. The testing was also performed to determine the measurement accuracy of the system and the response time of notification delivery. The data obtained from the testing were analyzed based on the measured water levels and the time required for data updates on the Blynk dashboard and for users to receive warning notifications.

RESULT AND DISCUSSION

The test results showed that the developed Water Level Monitoring System successfully detected changes in water levels ranging from 2 cm to 400 cm. Based on the tests conducted, the system recorded a measurement error of less than 5%. This finding demonstrates that the HC-SR04 ultrasonic sensor can be used to detect changes in the water surface distance within the developed system.

In terms of local indication, the red and green LEDs responded to changes in water levels according to the predefined water level conditions. This function allows users to identify the water level status directly from the prototype without relying on a mobile application.

For remote monitoring, the Blynk dashboard successfully received data updates at 2-second intervals. This capability enables water level information to be displayed periodically to users through a Wi-Fi connection. In addition, the system successfully delivered warning notifications within 3 seconds after the water level reached the predetermined high threshold.

Overall, the findings indicate that the developed system successfully performed its main functions, including water level detection, local status indication, remote monitoring, and warning notification delivery. However, the testing reported in this study focused primarily on the initial evaluation of measurement accuracy and system response time. Therefore, further testing under a wider range of operating conditions and with a larger number of measurement samples is required to evaluate the system's performance more comprehensively.

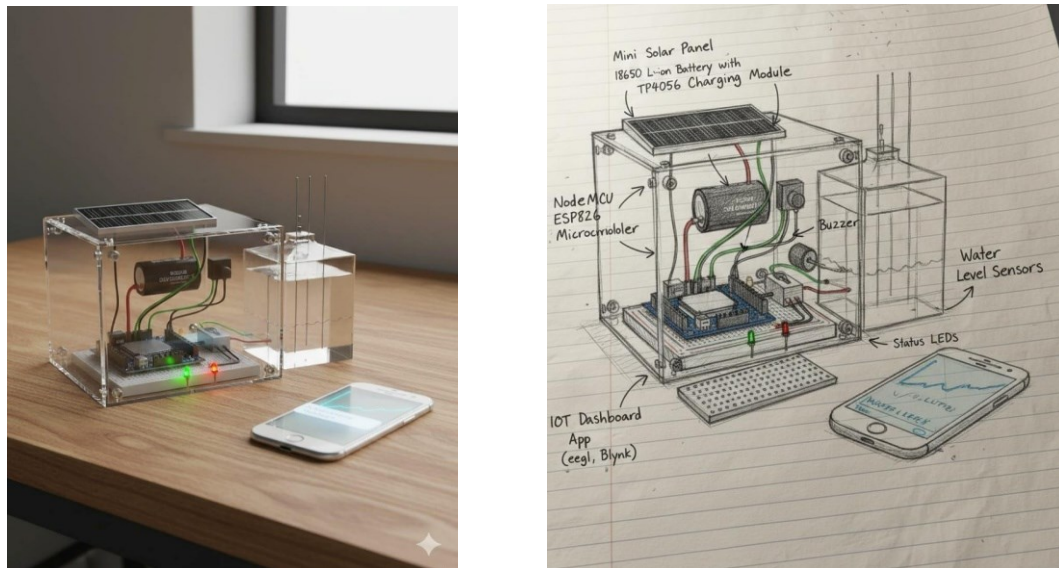


Figure 1. Water Level Monitoring System

CONCLUSIONS

The development of the Water Level Monitoring System demonstrates the potential of Internet of Things (IoT) technology for real-time water level monitoring. The integration of the ESP32, HC-SR04 ultrasonic sensor, and Blynk platform enables water level information to be monitored remotely and provides notifications when the water level reaches a predetermined threshold. This approach has the potential to reduce reliance on manual monitoring, particularly in domestic water tank and small-scale industrial applications.

From a research perspective, the developed system can serve as a foundation for future improvements, including testing under a wider range of operating conditions, enhancing measurement accuracy, and expanding the monitoring functions. For larger-scale applications, a similar approach could potentially be further developed for water level monitoring and early warning systems, subject to more comprehensive testing and performance validation.

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DEVELOPMENT OF WEARABLE HEALTH MONITORING WRISTBAND BASED ON ESP32

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Abstract: Wearable health monitoring devices have become increasingly important for providing convenient and continuous monitoring of basic physiological parameters. This study presents the development of a wearable health monitoring wristband based on the ESP32 microcontroller for monitoring body temperature and heart rate in real time. The proposed system integrates a MAX30102 sensor for heart rate measurement and a temperature sensor for monitoring body temperature. The ESP32 processes the sensor readings and evaluates the measured values according to predefined threshold levels. When the temperature is within the predefined normal range, the system reports a normal condition. If an abnormal temperature or heart rate value is detected, an alert notification is automatically transmitted to the user through the Telegram messaging platform using the ESP32 Wi-Fi connectivity. The measured values are also displayed locally to allow users to observe their current health parameters. The prototype was developed using an Arduino-compatible programming environment and tested under normal resting conditions. The results demonstrated that the wristband was able to obtain temperature and heart rate readings and successfully transmit monitoring information and alerts through Telegram. The developed prototype provides a low-cost and portable approach for preliminary health monitoring and remote notification.

Keywords: ESP32, wearable device, health monitoring, heart rate, body temperature, Telegram.

INTRODUCTION

The development of Internet of Things (IoT) technology has created opportunities for healthcare monitoring systems that can provide physiological information remotely and in real time. Conventional health monitoring generally requires users to visit healthcare facilities for measurements, while wearable devices can provide a more convenient method for observing basic health parameters during daily activities. Wearable health monitoring devices can be developed using low-cost microcontrollers and biomedical sensors, making them suitable for educational, research, and preliminary monitoring applications.

The ESP32 is a suitable microcontroller for wearable IoT applications because it provides integrated Wi-Fi connectivity, sufficient processing capability, and multiple interfaces for sensor integration. Previous studies have demonstrated the use of ESP32 with MAX30102 sensors for monitoring heart rate and other physiological parameters. The MAX30102 uses photoplethysmography (PPG) technology and is designed for heart-rate and pulse-oximetry applications in mobile and wearable devices [1]. ESP32-based health monitoring systems have also been developed using temperature sensors and remote monitoring platforms [2], [3].

However, a useful wearable monitoring system should not only display measurements but also provide immediate information when an abnormal condition is detected. Therefore, this project integrates Telegram as a remote notification platform. Telegram allows the ESP32 to send monitoring messages through the Internet, enabling users to receive information without continuously observing the wristband display. Similar research has demonstrated the integration of ESP32, heart-rate monitoring and Telegram-based notification for real-time monitoring [4].

The objective of this study is to develop a wearable health monitoring wristband based on ESP32 that can measure body temperature and heart rate, classify the readings according to predefined thresholds, and provide real-time monitoring and notification through Telegram.

METHODOLOGY

This system consists of an ESP32 microcontroller, a MAX30102 heart-rate sensor, a temperature sensor, a display unit and a Telegram notification system. The ESP32 acts as the main controller responsible for collecting sensor data, processing the measurements, determining the health status and transmitting notifications through Wi-Fi.

The MAX30102 sensor is used to obtain the user's heart rate in beats per minute (BPM). The temperature sensor measures the user's body temperature. The sensor readings are processed by the ESP32 and compared with predefined threshold values. The system then determines whether the measured condition is within the defined normal range or requires attention.

The overall operation can be summarized in Figure 1:

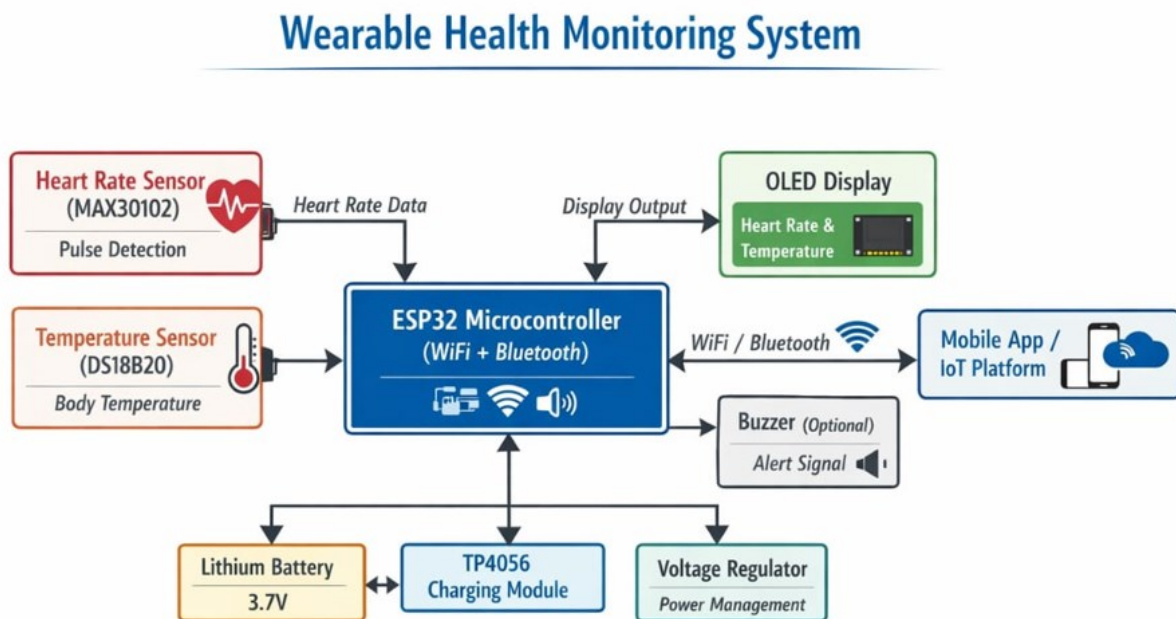


Figure 1. Block diagram of Wareable Health Monitoring System

RESULT AND DISCUSSION

The developed prototype successfully integrated the ESP32, temperature sensor, MAX30102 and Telegram notification function into a wearable wristband. During the functional test, the system was able to obtain temperature and heart-rate readings and display the measurements locally. The heart-rate sensor produced BPM readings that changed according to the user's physiological condition. During resting conditions, the readings were generally within the expected resting range. The temperature sensor also provided temperature measurements that could be processed by the ESP32. The Telegram communication test demonstrated that the ESP32 was able to transmit the measured parameters through a Wi-Fi connection. When the measured values were within the programmed limits, a normal-status message was generated. When a value exceeded the predefined threshold, an alert message was generated to inform the user that attention was required.

Table 1. Wearable Health Monitoring System Output

Parameter	Monitoring Function	Output
Body Temperature	Measures body temperature	Temperature value and status
Heart Rate	Measures BPM	BPM value and status
ESP32	Processes sensor data	Health classification
OLED	Local monitoring	Real-time readings
Telegram	Remote notification	Normal/abnormal alert

Based on the results in Table 1, the results indicate that the developed system can perform the main functions intended for the system, namely physiological data acquisition, basic condition classification and remote notification. Figure 2 shows the Wearable Health Monitoring System.



Figure 2. Wearable Health Monitoring System

The development results demonstrate the potential of ESP32 as the main controller for a compact wearable health monitoring system. Its integrated Wi-Fi capability reduces the need for an additional communication module and allows sensor measurements to be transmitted directly to an online messaging platform. This is particularly useful for applications where the user or caregiver needs to receive monitoring information remotely.

The MAX30102 is suitable for wearable heart-rate monitoring because it is specifically designed for mobile and wearable applications. Previous work has successfully integrated MAX30102 with ESP32 for heart-rate monitoring and demonstrated that the combination can provide physiological measurements through an IoT-based system [1]. Other studies have also demonstrated ESP32-based wearable systems incorporating heart rate and temperature monitoring [2], [3].

The Telegram notification feature improves the functionality of the proposed system compared with a device that only displays readings locally (refer figure 3). Instead of requiring the user to continuously check the wristband, the system can provide a notification when a predefined abnormal condition is detected. This approach is also consistent with recent ESP32-based health monitoring research integrating Telegram for real-time heart-rate notifications [4].

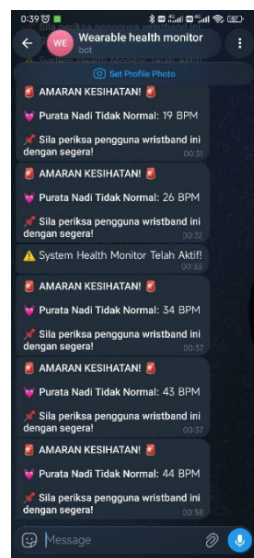


Figure 3. Telegram for Wearable Health Monitoring System

Nevertheless, several limitations should be considered. Body temperature measured from the wrist may differ from clinical core-body-temperature measurements. Heart-rate measurements can also be affected by movement, sensor placement and contact quality. Previous studies have reported that motion artefacts can affect heart-rate measurements obtained using optical sensors [2]. Therefore, the proposed wristband should be considered a preliminary monitoring prototype rather than a replacement for certified medical equipment.

CONCLUSIONS

This study presented the development of a wearable health monitoring wristband based on ESP32 for monitoring body temperature and heart rate. The system integrates a MAX30102 heart-rate sensor, temperature sensor, local display and Telegram notification system. The ESP32 successfully processes the sensor measurements and provides normal or abnormal status information based on predefined thresholds.

The integration of Telegram provides an additional advantage by allowing health monitoring information and alerts to be received remotely through an Internet connection. Overall, the prototype demonstrates the feasibility of combining wearable sensing, ESP32 and IoT communication for preliminary health monitoring. Further development is required to improve measurement accuracy, power efficiency, comfort and validation against certified medical devices before the system can be considered for clinical applications.

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